



IJMAA – ODOR CONTROL SYSTEM

JEBB JENNINE SOLID WASTE TREATMENT FACILITY

TENDER DOCUMENTS

Particular Technical Specifications

PARTICULAR SPECIFICATIONS

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VOLUME 2: Particular Technical Specifications

The Contractor has to comply with in full with the terms and requirements of the

GENERAL TECHNICAL SPECIFICATIONS;

except insofar as the

PARTICULAR TECHNICAL SPECIFICATIONS

as set out in these Sections may amend them.

The provisions of Particular Specifications shall prevail over General Specifications

1. PARTICULAR TECHNICAL SPECIFICATIONS AND PRELIMINARIES

1.1 INTRODUCTION

The scope of works of the present contract comprises the construction an odor control and treatment unit pertaining to the existing Jebb Jennine solid waste treatment facility.

Indeed, one of the major challenges towards the social and environmental acceptance of the facility is the waste gas produced due to degradation of organic waste in the facility's composting plant, which needs to be extracted and treated.

As such, in order to ensure the environmental sustainability and social acceptability of the facility's operations, the present project aims to construct, install, test and commission an odor control system for the facility in Jebb Jennine.

The system is composed of a biofilter odor control system working on the basis of biofiltration, equipped with a pre-scrubber to humidify the inlet fouled air and in provision for peak ammonia concentrations; complete including all associated civil, electrical and mechanical works and including the installation of air extraction fans (centrifugal fans to extract the air from the facility composting plant, and axial fans to push air from the sorting hangar to the composting hangar; with their associated air extraction and collection systems) and other associated amenities as described elsewhere in these Tender Documents.

The project site is located in the Bekaa region of Lebanon, namely the Jebb Jennine solid waste treatment facility located in the village of Jebb Jennine, which has recently been commissioned for the Union of Municipalities of Bouhayra.

1.2 SITE LOCATION

Joub Janine (جب جنين) is located in West Bekaa District (Qada'a), an administrative division of Beqaa Governorate (Mohafazah).



The Jebb Jennine waste treatment facilities is designed to serve all the villages members of the Municipalities Union of Bouhayra, of which Joub Janine is a member as well.

Joub Janine is 68 kilometers to the east of Beirut, the capital of Lebanon and around 25 km to the west of Masnaa, the Lebanese eastern border with Syria. Its elevation is of 930 meters above sea level. Joub Janine surface stretches for 1575 hectares (15.75 km²).

The site can be accessed the route Joub Janine – Ghazze. The site is located between Ghazze (4.5 km to the south west) and Joub Janine (3.5 km to the North). The existing site is in the Beqaa Valley, surrounded by agricultural lots and is around 250 m to the east of the Litani River.



Figure 1: Aerial view of the plant location

1.3 GENERAL DESCRIPTION OF THE EXISTING JEBB JENNINE SOLID WASTE TREATMENT FACILITY

The plant, is a mechanical biological treatment (MBT) consisting of:

- A sorting hangar (dimensions around 50 m x 30 m x a height varying between 5.4m on the sides and 8.4m in the centre).
- A composting hangar (dimensions around 60 m x 30 m x a height varying between 5.4m on the sides and 8.4m in the centre)
- An adjacent landfill, including:
 - o A basal lining system:
 - o A landfill gas (methane) extraction system. The methane contained in the landfill gas shall be transported through a passive landfill vent.
 - o A leachate extraction and collection system. Indeed, the basin of the landfill is shaped to have slopes draining the leachate towards the deepest point of the landfill. A pump for leachate is implemented at this point in order to transfer the leachate to the collection tank constructed at the eastern part of the site.

The area of the site for the waste management facilities including the sorting and composting facilities is around 45,000 m². In the southern part of the site, hangars for the sorting and composting facilities have already been constructed, as well as a building for administration. On the northern part, an area of around 21,000 m² is dedicated for the landfill exploitation. On the eastern part the area is used for the construction of the leachate tank and the access road to the landfill.

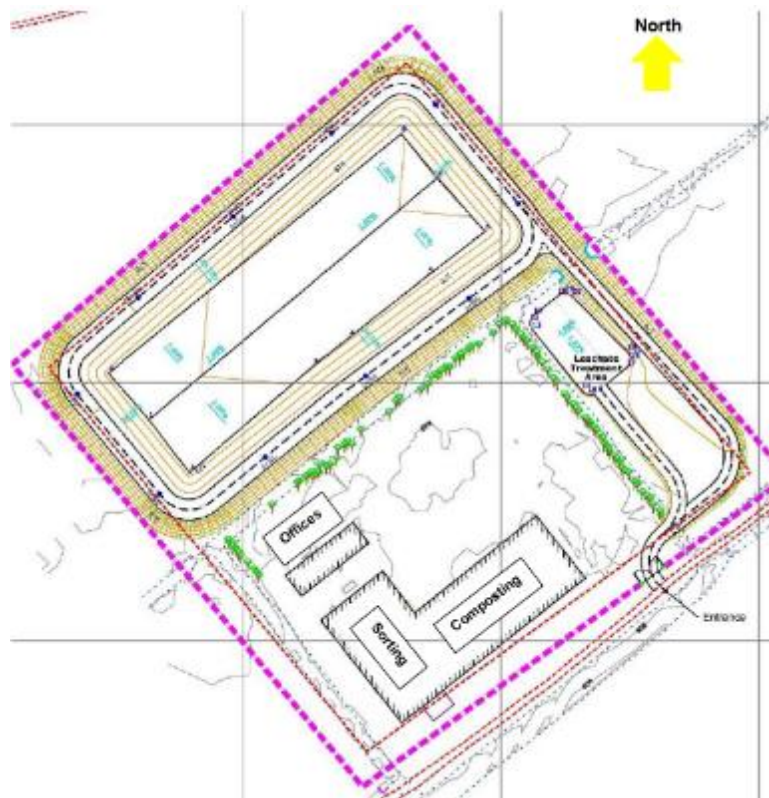


Figure 2: General layout of the solid waste treatment facility

According to the Union of Municipalities of Bouhayra, the capacity of the sorting and composting facility is around 100 T/d of municipal solid waste. It is destined to treat and process solid waste from 18 municipalities within the Union.

One of the major challenges is the waste gas produced due to degradation of organic waste in the composting plant in Jeb-Jennine and needs to be extracted and treated.

As such, in order to ensure the environmental sustainability and social acceptability of the facility's operations, the present project aims to construct, install, test and commission an odor control system for the facility in Jebb Jennine.

The primary purposes of odor control in the solid waste treatment facility are summarized as follows:

- Confine and extract odors in order to treat them and prevent the discharge of unpleasant smells into the environment.
- Fight against excessive air pollution inside buildings and provide satisfactory working conditions for operation and maintenance personnel
- Limit gas concentrations in the air space inside closed structures, in order to protect equipment and concrete structures.

The implementation of the system will thus enforce the social acceptance of the facility after reduction of gases emissions that will reduce the odorous nuisance.

The required odor management system will consist of:

- A collection and ventilation system composed of:
 - o Axial fans extracting air from the sorting hangar and injecting it into the composting hangar
 - o An extraction and collection duct system spanning the periphery of the composting hangar and till the odor control unit

- Centrifugal fans extracting fouled air from the composting hangar to the odor control unit
- An odor control and treatment unit composed of a biofilter odor control system working on the basis of biofiltration, equipped with a pre-scrubber to humidify the inlet fouled air and in provision for peak ammonia concentrations

The proposed odor control system aims to treat the typically emanated odorous components, mainly H₂S, NH₃, R-SH and other odorous components. The adoption of such well-known treatment is related to the advantages of cost effectiveness, reliability (as it uses simple elements) and other advantages with respect to conventional odor treatment processes as described in sections hereafter.

1.4 SCOPE OF WORKS

The scope of work shall include but not necessarily limited to the following elements:

- Mobilization/demobilization, site survey
- The construction of an odor control and treatment unit composed of a biofilter odor control system working on the basis of biofiltration, equipped with a pre-scrubber to humidify the inlet fouled air and in provision for peak ammonia concentrations; complete including all associated civil, electrical and mechanical works and including the installation of air extraction fans (centrifugal fans to extract the air from the facility composting plant, and axial fans to push air from the sorting hangar to the composting hangar; with their associated air extraction and collection systems) and other associated amenities as described elsewhere in these Tender Documents
- The closure of the partially open sorting hangar and the open composting hangar to allow efficient air extraction from them
- Testing and commissioning
- Preparation of all necessary shop drawings, material / equipment submittals, operation & maintenance manuals, as-built documentation
- Obligations during defects liability

1.5 GENERAL REMARKS:

Subject to the requirements and limitation of the contract, the Contractor shall be prepare the construction and shop drawings, subject to the directions and approval of the Engineer.

- All mechanical and electrical equipment shall operate without restriction on continuous full-load conditions under the following climatic conditions as the minimum requirement:
 - Max. temperature: 50 °C
 - Min. temperature: -5 °C
 - Relative humidity: 100 %

The equipment, cables, wires shall be de-rated by appropriate factors given by the manufacturers and in the latest edition of the I.E.E. regulation.

- Special attention has to be paid to the difficult climate condition within the project area (cold weather, snow, humidity, etc.) as well as the very strong UV radiation.
- These specifications shall be read in conjunction with all other contract documents and the Contractor shall comply with all the provisions contained in these documents. The contract documents are deemed to be complementary and to describe and provide for the complete works.

- In case of contradiction or discrepancy between any two or more articles or clauses of this specification, the clause, which stipulates the more restrictive condition for the Contractor shall be binding.

1.6 CONSTRUCTION DOCUMENTS AND SHOP DRAWINGS

1.6.1 GENERAL

The Contractor shall prepare and submit to the Engineer for his approval, within the times stated below or given in a program approved in accordance with the Contract, the necessary Construction Documents and Shop Drawings, As-Built Drawings, Operation, Maintenance and Safety Manuals and Training Manuals as may be called for therein or as the Engineer may require.

The Engineer shall have the right at all reasonable times to inspect all Contractor's Construction and other Documents of any part of the Works at the premises of the Contractor, his Subcontractors and suppliers.

Any cost resulting from a delay in delivery by the Contractor of any of the Construction Documents and other information required under the Contract shall be borne by the Contractor.

All Construction Documents shall be submitted according to an approved programme of submissions in three (3) copies to the Engineer for approval.

Once approval has been obtained, a further five (3) prints of each submission shall be submitted, which shall be deemed to be the final drawings to which the Plant and the Works shall be manufactured and/or installed and constructed.

All drawings, whether produced manually or by CAD, shall be in the form of dark lines on white background and shall bear the following information within a standard title block to be approved by the Engineer: Project Name, Contract No., Package No., Drawing Title, Scale, Date of preparation, Type and Date of revisions, Drawing and Revision No. If so requested by the Engineer, some of the drawings shall be prepared in color or shall be colored.

All layout and arrangement drawings shall be to scale and shall include a graphical scale to aid the use of photographic reproductions. All dimensions shall be given in SI metric units. Drawings shall normally not exceed A1 size.

The Contractor shall submit drawings and supportive data to the Engineer for his approval at the stages described as follows:

- Construction Documents and Shop Drawings before start of manufacture or construction in accordance with the approved programme,
- As-Built Drawings and documents before the project completion in accordance with the approved programme,
- Operation, Maintenance and Safety Manuals three (3) months before the anticipated date of the Testing and Commissioning.

All technical documents to be submitted by the Contractor shall be prepared in English language.

1.6.2 AS-BUILT DRAWINGS

The As-Built Drawings shall comprise, but not be limited to the as-built conditions of all civil, steel, mechanical, electrical, instrumentation and control works as approved by the Engineer and shall be submitted for review and approval.

If, after submission of the As-Built Drawings as mentioned above until the date of the Defect Liability Certificate, changes in the Works are carried out by the Contractor, he shall amend the As-Built Drawings accordingly and submit them again to the Engineer for review and approval.

1.6.3 OPERATION, MAINTENANCE AND SAFETY MANUALS

The Contractor shall provide three (3) sets of comprehensive Operation, Maintenance and Safety Manuals in both English and Arabic, each with two sets of drawings at least three (3) months before the anticipated date of the Testing and Commissioning.

These Manuals shall describe in sufficient detail for the Employer to operate, maintain, dismantle, reassemble, adjust and repair the Works and shall include necessary safety instructions for Operation and Maintenance.

Specific items of the Works shall be described in detail so that no ambiguity arises.

A collection of standard pamphlets of general nature unaccompanied by detailed drawings and descriptions relating to the installed equipment and Plant will not be accepted.

Any operation likely to be carried out during the life of the solid waste treatment facility shall be described in the form of a step by step procedure and shall include annotated drawings, tolerances, charts or diagrams to indicate the requirements for:

- safety precautions,
- dismantling,
- reassembling,
- operation,
- monitoring and control,
- adjustment,
- identification of faults,
- testing,
- inspection,
- lubrication,
- preventive maintenance,
- routine maintenance,
- replacement of worn parts and overhauls,
- ordering of spare parts.

The types and grades of all lubricants required for maintenance shall be listed in a lubrication chart which shall include a schedule for routine maintenance to ensure trouble-free operation.

All items that will be subjected to wear during service shall be illustrated. Guide lines shall be provided

on the maximum permissible wear before any such item needs replacing.

The methods for measuring the wear with lists of tolerances and other dimensional limits shall be included. A list of items and minimum quantities that are recommended as spare parts shall be provided.

Staff training for a period of 2 weeks shall be provided by the Contractor to the operators of the solid waste treatment facility to ensure transfer of skills and knowledge required for the proper and efficient operation of the ventilation system and biofilter odor control system.

1.7 PROVISIONAL SUMS

Provisional Sums have been included in the Contract at the amounts as stated in the Bill of Quantities.

Provisional Items or Provisional Sums shall be used at the discretion of the Engineer and only if ordered or required by the Engineer in writing.

The existence of the Provisional Sums does in no way entitle the Contractor to any claim and/or additional payment for fulfilling his obligations described in the Contract.

The Contractor shall carry out at his expenses, the coordination and follow up of the execution of the works with the concerned authorities.

2. PARTICULAR TECHNICAL SPECIFICATIONS OF THE WORKS

2.0 GENERAL

2.0.1 TOPOGRAPHY OF THE WWTP SITE

Topographical maps showing the shape and the surface levels of the existing sites as well as maps showing the site plots boundaries are enclosed.

The Contractor shall, at his cost, carry out all the necessary complementary soil surveys and geotechnical investigations, subject to the approval of the Engineer.

2.0.2 PLATFORM, FLOOD AND RIVER PROTECTION AND EARTH CHANNELS

The Contractor shall execute a platform, and execute the necessary works to ensure the protection of the plant.

The odor control and treatment system will be set out to be protected from flooding by the storm water. The Contractor shall execute a platform, and execute the necessary works to ensure the protection of the plant, as shown of the drawings. The levels of excavation and of the platform and structures are shown on the drawings. However, the exact levels shall be finalized on site based on the encountered site conditions, and according to the instructions of the Engineer.

2.0.3 NOTE REGARDING CONTINUITY OF WORKS

The Contractor shall coordinate with the municipality and the operator of the Jebb Jennine solid waste treatment facility to ensure the continuity of the operation of the facility (reception of waste, processing and sorting of waste, composting of organic waste, processing of recyclables, etc. and all regular operation activities) during the period of execution of the works pertaining to the present project.

The Contractor shall also phase the works properly in order to ensure the health and safety of the workers as well as the operators of the plant on all aspects and notably with respect to the changes of air conditions following closing operations of hangars. The Contractor shall take all necessary measures regarding health and safety during the construction works in aggressive conditions.

2.1 SECTION 1: PRELIMINARIES AND GENERAL TECHNICAL REQUIREMENTS

The particular specifications concerning this Section have been included in the various Sections of the present document.

2.2 SECTION 2: EXCAVATION AND EARTHWORKS

2.2.1 SITE PREPARATION AND CLEARANCE

Site preparation and clearance shall be carried out to the satisfaction of the Engineer to enable and facilitate all new construction.

2.2.2 EXCAVATION

A typical excavation/site preparation and clearance of a depth of 30cm is normally foreseen to eliminate the organic or inadequate top soil.

General excavation shall be carried out according to the dimensions shown on the Drawings so as to create the void to be occupied by the permanent construction.

Excavation in structures shall be carried out according to the dimensions shown on the Drawings so as to create the void to be occupied by the permanent construction.

However, the bottom level of excavation will be determined on site by the Engineer depending on the encountered soil conditions according to the instructions of the Engineer.

2.2.3 FILLING AND BACKFILLING

- All fill/backfill and borrow fill/backfill material shall conform to the specifications, shall be of good quality compatible and suitable for the zones to be filled, and shall be approved by the Engineer.
- Filling and backfilling levels are shown on the drawings. However, the levels to be adopted during execution of filling and backfilling shall be according to the directions of the Engineer.

The fill material between the adopted bottom level of excavation and the structures and finished levels in the zones stated hereabove are shown on the drawings to be executed (below the concrete structures to be executed, and other areas) shall be according to the drawings, specifications and directions of the Engineer and in function of the encountered soil conditions (specific instructions of the Engineer is required in this respect before the execution of the works). It shall be according to the following:

- Approved compacted base course (road base) layer, approved compacted sub-base layers, with geotextile filter, according to the drawings specifications, to achieve a safe bearing pressure of 140kPa to not exceed a maximum settlement of 50mm.

The various layers of the system will be as follows:

- Grading and compaction of the natural ground level after excavation to a dry density not less than 95% of the Optimum Standard Proctor dry density.
- Installation of a geotextile layer (250g/m²) above the compacted natural ground level after excavation, according to the specifications herebelow
- Execution of layers of compacted sub-base course, with a compacted thickness of 20cm for each layer, compacted to 98% of Optimum Modified Proctor dry density (in conformity with the specifications of the sub-base course, but the

sub-base shall have a 4-day soaked CBR of not less than 50% when compacted at 100% modified Proctor (AASHTO T180-D) and tested in accordance with AASHTO T193.

- Execution of layers of compacted base course (road base) with a compacted thickness of 20cm for each layer, compacted to 98% of Optimum Modified Proctor dry density (in conformity with the specifications of the road base (base course) layers. The base course (road base) shall have a 4-day soaked CBR of not less than 70% when compacted at 100% modified Proctor (AASHTO T180-D) and tested in accordance with AASHTO T193). The top level of the layer of compacted base course (road base) should reach the foundation / slab on grade levels
- On the top of the road base (base course) layer, it should be achieved a safe bearing pressure of 140kPa to not exceed a maximum settlement of 50mm.
- Installation of a damp-proof membrane above the base course layer

The wall footings of the biofilter system will also be laid on the following two layers (from top to bottom):

- A 40cm thick minimum well graded base course layer (CBR 70%),
- A 60cm thick minimum well graded subbase course layer (CBR 50%),

The bottom slab of the biofilter system will be laid on the following two layers (from top to bottom):

- A 40cm thick minimum well graded base course layer (CBR 70%),
- A 30cm thick minimum well graded subbase course layer (CBR 50%),

Regarding the borrow materials for base course (road base) sub-base, the tests to be carried out are as follows:

- Particle size (sieve analysis)
- Atterberg Limits
- Natural water content
- Organic matter
- Modified Proctor Test
- "Los Angeles" Abrasion Test

During the execution of the works: for each compacted layer, in-situ tests (water content and dry density) shall be carried out on each collected sample.

- **Tests Frequency**

Tests on borrow material for base course (road base) and sub-base shall be carried out on each 1500 m³ of borrow material (the number of test series will be determined by the Engineer), provided that the sample taken is representative of such a volume. The Engineer reserves the right to increase the frequency depending on the conditions on the site.

During the execution of the work relative to the base course (road base) and sub-base, tests will be conducted on the executed layers as follows:

- Following the installation and compaction, and in the aim to control the proper execution of the materials, installation and compaction, two in-situ tests series or laboratory tests

series (as required and applicable) shall be carried out by fill layer or every 500 m3 of executed fill. Where the volume of an executed layer is lower than 500 m3, the two test series shall necessarily be carried out.

- In addition, a control of fill (at the level of foundations as well as at the levels of slab on grade) shall be carried out by plate load tests, by the Contractor at his own expense in order to confirm meeting the required following characteristics: safe bearing pressure of 140kPa to not exceed a maximum settlement of 50mm, as stated here above. Plate load tests shall be carried out to confirm the results. The frequency will be one every 500 m2 or more based on the judgment of the Engineer.

2.2.4 GEOTEXTILE

Geotextile shall be installed as follows:

- Drainage, filtration and protection geotextile (250g/m²) non-woven polypropylene stabilized against UV: above the compacted natural ground level after excavation, at the location of the foreseen platform level, according to the specifications, drawings and instructions of the Engineer

Geotextile rolls shall be of the non-woven heavy-duty type, needle punched, non-biodegradable, and shall consist of long chain polymeric filaments of polypropylene, UV stabilized. The fabric shall be a stable network of fibres, which retain their positions relative to each other.

The geotextile shall be suitable for proposed use, able to meet the hard conditions of usage over a lasting period, and shall be approved by the Engineer.

Property	Test Method	Units	Property Requirement	
			MD	X-MD
Tensile Strength	EN ISO 10 319	KN/M	18-22	18-22
Elongation at maximum tensile strength	EN ISO 10 319	%	50	50
Puncture CBR	EN ISO 12 236	KN	3.5- 4.0	
Opening Size O ₉₀	EN ISO 12 956	um	Function of the overlaying layer (as required by the Engineer)	
UV Resistance	EN ISO 12 224	%	100%	

Geotextiles shall be furnished in 5m wide rolls wrapped with protective covering to protect them against ultraviolet radiation and abrasion. Torn wrappers shall be repaired within 48 hours, using an approved protective covering, each roll of fabric shall be marked or tagged to identify the manufacturer, type, length, width, and production identification number.

The geotextile shall be covered (following the manufacturer recommendation) as soon as possible after installation.

• Joints and overlaps:

Geotextiles can be assembled by an overlap and seam according to the position and function. Horizontal joints will not be permitted on side slopes.

- On the slopes above 1/10, it is recommended that the geotextiles are sewn continuously throughout the length of the seal. Geotextiles shall be overlapped with a minimum of 10 cm before being sewn.
- On the slopes lower than 1/10, the geotextiles can be sewn with minimum 10 cm overlaps. In case of heat assembling, the geotextiles shall be overlapped by a minimum of 20 cm before being sewn.

- **Repairs:**

All holes and tears in the geotextile shall be repaired as follows:

- On the slopes, a patching compound of the same material of the geotextile will be joined on site. If a tear is exceeding 10% of the width of the roller, the roller is removed from the slope and replaced.
- On horizontal surfaces, a patching compound of the same material of the geotextile will be joined on site with a minimum of 30 cm of overlap in all directions.

Furthermore, the installation should be conducted according to the norms, state of the art requirements, manufacturer recommendations and by a qualified installer, subject to the approval of the Engineer. The Contractor shall submit to the approval of the Engineer a complete documentation including technical characteristics and tests, certification documents, qualification of installer, method statement, layout schedule, etc.

2.3 SECTION 3: CONCRETE WORKS

- Exposed face of all structures shall be formed by wrought formwork (Fair-face Grade A appearance). All other surfaces of reinforced concrete structures shall be executed by means of wrought formwork.
- Formwork for all concrete surfaces shall be of form panels (marine plywood or metallic formwork) in order to obtain a regular and smooth finish.
- For aggressive environment such as for the biofilter system, Sulphate Resistant Portland Cement (SRPC type V) shall be used.
- Through-bolts or ties will not be permitted in liquid-retaining structures. The Contractor shall use only such bolts or ties as are capable of being removed in whole. In fact, special types of formwork shall be used, including internal galvanized steel joints for the tie rods (joints embedded at the center of the concrete, and acting as waterstops), and allowing the complete removal of the tie rods. The voids shall be filled with special non-shrink mortar and special products approved by the Engineer.
- On the horizontal concrete surfaces (where formwork is not applicable), a mechanical steel trowel surface finishes shall be formed while the concrete is still wet by means of a mechanical steel trowel.
- In addition, the preparation of all surfaces shall be carried out to suit the installation of the various coatings and coverings.
- Chamfers (25 mm x 25 mm) shall be formed to all exposed external angles
- Construction joints (construction, expansion, contraction, etc.), skewbacks, stunt ends, steppings, bonding chases and the like, including formwork, joint, joint filler, joint sealant, backing rod, water bars, waterstops, angles and accessories, treatment of reinforcement crossing the joint, treatment of concrete joint faces, preparation of surfaces, cleaners, primers, sealers, backing strips and bond breakers, dowel bars for expansion joints (whether shown or not on the Drawings or in the specifications, or directed by the Engineer, or judged necessary during the execution of the works) shall be executed.

The width of the waterstop shall depend on the thickness of the corresponding structure in which the waterstop is installed. The minimum width of the waterstop shall be 60% of the thickness of the structure, with a minimum of 20cm and a maximum of 30cm.

The type of waterstop shall depend on its specific use (in construction joint, expansion joint, etc)

Construction joints shall only be formed at positions as directed by the Engineer.

- Joint filler for joints in structures to retain aqueous liquids shall be self expanding cork, natural bonded cork, resin bonded cork, or other material as directed by the Engineer. Joint filler shall be cut and trimmed accurately to suit the joint profile and shall be maintained accurately in position by means of an approved adhesive. Self expanding cork filler shall consist of cork granules bound together with an insoluble synthetic resin. Cork filler shall have maximum water absorption of 0.3% by volume when tested in accordance with ASTM D3595. The load required to compress the filler to 50% of its original thickness shall not exceed 1.5 N/mm² for self expanding cork (moist), 0.6 N/mm² for resin bonded cork and 0.90 N/mm² for natural bonded cork. Recovery after compression test shall exceed 90%.

Joint filler in non water retaining concrete structures shall be non-extruded bitumen impregnated fibreboard.

- Joint sealants:
Joint sealing compounds shall be impermeable ductile materials of a type suitable for the conditions of exposure in which they are to be placed, and capable of providing a durable, flexible and watertight seal by adhesion to the concrete throughout the range of joint movement.

In particular, the joint sealants to be applied on the slab on grades shall account for the aggressive conditions of exposure in which they are to be placed

- The necessary admixtures shall be foreseen, including among others: superplasticisers for the various structures, and waterproofing admixtures for the liquid retaining structures (to ensure the self-waterproofing and water tightness of the liquid retaining structures, including the biofilter concrete structure) (wastewater, leachate and water)
- Rain water strips shall be executed as directed by the Engineer.
- Concrete will be divided in the categories stated in the Bill of Quantities.
- Blinding concrete shall in addition include for preparation and compaction of the formation level and preparation and trimming of surfaces.
- A damp-proof membrane shall be laid beneath all floor slabs resting on the ground (including the slab of the complete biofilter system). They shall be laid on above the compacted layer of base course shown on the drawings, as recommended by the membrane manufacturer and as directed by the Engineer.
Damp-proof membranes shall be composed of single sheets of minimum thickness 0.250 mm black polyethylene film of an approved manufacturer specifically made for use as damp-proof membrane.
The film shall be laid on the compacted layer of base course and and turned up around all edges of the slab and with 150 mm margin above the top of the slab to be tucked

into the perimeter walls of the building. Where the buildings size is so large as to exceed the maximum sheet size available, several sheets shall be used and the joints shall be lapped 150 mm and fused together using a welding tool designed for that purpose. Every care shall be taken by the following trades to prevent perforation of the membrane but in the event of puncture the perforation shall be covered by a patch of similar material of dimensions exceeding the area of the puncture by 300 mm and the two sheets welded together as described above.

- Steel reinforcement bars for reinforced concrete work shall have the following characteristics: yield stress 420 N/mm², high tensile steel grade 60A.
- Steel reinforcement bars for stirrups and hoops for reinforced concrete work shall have the following characteristics: grade 40, unless otherwise specified where high tensile steel grade 60A shall been used.
- Concrete (plain and reinforced) will be divided in the following categories as stated in the Bill of Quantities and according to the directions of the Engineer:
 - Cast-in-place plain concrete, Cement Type II, 16 MPa, for blinding for foundation (various structures and buildings):

Cast-in-place plain concrete using Moderately Sulphate Resistant Cement to ASTM C150, Type II, 16 MPa on cylinder, shall be adopted for blinding for foundation beds (100 mm thick)
 - Cast-in-place reinforced concrete, Cement Type V, 30 MPa

Cast-in-place reinforced concrete using High Sulphate Resistant Cement to ASTM C150, Type V, 30 MPa on cylinder, shall be adopted for foundations, and slab on grades in aggressive environments (biofilter system) including ramps, steps, channels (with waterproofing admixture for channels), and any difference in levels
 - Cast-in-place reinforced concrete, Cement Type I, 30 MPa

Cast-in-place reinforced concrete using Ordinary Portland Cement to ASTM C150, Type I, 30 MPa on cylinder, in aggressive environment (i.e. for the closure of the partially open sorting hangar and the open composting hangar)

2.4 SECTION 4: PIPES AND PIPELAYING

The Contractor shall be responsible for carrying out the shop drawings of each section of the pipes. Copies of the shop drawings shall be submitted to the Engineer for approval.

These design calculations and shop drawings shall take into account the various factors involved including but not limited to the following:

- Encountered native soil conditions on the basis of the geotechnical investigation carried out by the Contractor
- Bedding material
- Type, class and characteristics of the selected pipe
- Cover above pipe
- Trench conditions
- Traffic conditions
- Thrust blocks

2.4.1 PIPEWORKS AND FITTINGS

The type of pipes shall be as shown on the drawings, described in the specifications, described in this section, directed by the Engineer, and are included in the Bill of Quantities.

Thrust blocks shall be foreseen for the pressure pipes.

2.4.2 MANHOLES

In addition to the requirements of the General Technical Specifications and drawings, the following specifications shall be applicable:

Wastewater manholes shall be constructed of Class "AA" reinforced concrete (cast-in-place reinforced concrete using High Sulphate Resistant Cement to ASTM C150, Type V, 30 Mpa on cylinder). Benching to the manholes shall be Class AA concrete.

Internal surfaces of manholes shall be coated with an approved anti-corrosive epoxy resin coating (coal tar epoxy) according to Section 11.6.2 of the General Specifications "Protection of concrete surfaces immersed in sewage or subjected to corrosion by splashing and/or condensation"

External surfaces of manholes above the water table shall be coated with an approved tar compound applied in two coats.

The PVC liner as specified in sections 4.6 and 11.6.2 of the General Technical Specifications shall not be foreseen for the protection of concrete surfaces in contact with sewage or H₂S.

2.4.3 PROTECTION OF EXTERIOR CONCRETE SURFACE

The protection of exterior concrete surface below ground level shall be according to Section 4.2.4 of the General Specifications "Protection of exterior concrete surface" as described herebelow.

The exterior surfaces of all manholes and structures shall be given two coats of an approved tar compound.

The Contractor shall produce documentary evidence that the tar compound proposed to be used is suitable for the intend purpose and has been successfully used in similar installations. Surfaces to be protected shall be dry and thoroughly cleaned from dust and loose material. Projections shall be removed and all defects shall be adequately repaired and made good before the application of the compound. The tar compound shall be applied in accordance with the manufacturer's instructions and recommendations and as directed or approved by the Engineer.

2.5 SECTION 5: PLUMBING, DRAINAGE AND DOMESTIC MECHANICAL WORKS

The specifications stated in Section 5 of the General Specifications are not applicable. They shall be substituted by Section 18 of the General Specifications "Plumbing, Drainage and Mechanical Works".

2.6 SECTION 6: BLOCKWORK

All blockwork shall be non-load bearing hollow blockwork, Ordinary Portland Cement (OPC type I).

2.7 SECTION 7: JOINERY AND IRONMONGERY

No particular specifications.

2.8 SECTION 8: METALWORK

All galvanized steel items such as ladders or step irons, safety chains, removable or hinged checker plate flooring, removable or hinged open mesh flooring, entrance roller shutter, and galvanized steel walkway and stairs, shall be treated and painted according to the specifications.

All non galvanized steel items such as steel handrails and guardrails, metallic doors, entrance metallic door shall be treated and painted according to the specifications.

2.8.1 METALLIC DOOR

Metallic doors shall be executed in steel. The composting hangar accessways of the Jebb Jennine treatment facility shall be closed by the means of a manually operated two-leaves painted metallic sliding door of dimensions, height 5.4m x width 4.5m composed of two 1.2mm corrugated steel panels sandwiched by metal reinforcement, as stated in the specifications, shown on the drawings, specified in the Bill of Quantities, or directed by the Engineer.

The thickness and characteristics of doors shall be according to the norms so as to withstand the potentially applied loads and accident impacts.

Panels for doors shall be in painted galvanized steel cladding, as produced by "Kirby", "Butler" or "Zamil", 1.2mm for the corrugated steel panels sandwiched by metal reinforcement, pertaining to the manually operated two-leaves painted metallic sliding door.

Panels shall conform to ASTM A792 Grade 50 B, and shall be hot dip coated with a corrosion resistant Zinc/Aluminum alloy with 150 g/m².

The exterior exposed surface shall be coated with silicon modified polyester paint. The interior exposed surface shall be coated with polyester paint.

2.8.2 STRUCTURAL STEEL

PART 1 - GENERAL

1.1. SUMMARY

Section includes structural steel framing members, support members, suspension cables, sag rods, and struts; base or bearing plates, shear stud connectors, and expansion joint plates; anchor bolts for structural steel; beams, girders, purlins, and girts; bearing of steel for girders, trusses or bridges; bracing; columns, posts; connecting materials for framing structural steel to structural steel; crane rails, splices, stops, bolts, and clamps; door frames constituting part of structural steel frame; expansion joints connected to structural steel frame; fasteners for connecting structural steel items; permanent shop bolts; shop bolts for shipment; field bolts for permanent connections; permanent pins; floor plates (checkered or plain) attached to structural steel frame; grillage beams and girders; hangers essential to structural steel frame; leveling plates, wedges, shims, and leveling screws; lintels, when attached to structural steel frame; trusses; and grouting under base plates.

1.2. REFERENCES (Equivalent Equal Acceptable)

- A. American Institute of Steel Construction:
 - 1. AISC S303 - Code of Standard Practice for Steel Buildings and Bridges.
- B. ASTM International:

1. ASTM A6/A6M - Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling.
 2. ASTM A36/A36M - Standard Specification for Carbon Structural Steel.
 3. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 4. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 5. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 6. ASTM A242/A242M - Standard Specification for High-Strength Low-Alloy Structural Steel.
 7. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength.
 8. ASTM A325M - Standard Specification for High-Strength Bolts for Structural Steel Joints (Metric).
 9. ASTM A449 - Standard Specification for Quenched and Tempered Steel Bolts and Studs.
 10. ASTM A490M - Standard Specification for High-Strength Steel Bolts, Classes 10.9 and 10.9.3, for Structural Steel Joints (Metric).
 11. ASTM A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
 12. ASTM A501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
 13. ASTM A514/A514M - Standard Specification for High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding.
 14. ASTM A529/A529M - Standard Specification for High-Strength Carbon-Manganese Steel of Structural Quality.
 15. ASTM A563M - Standard Specification for Carbon and Alloy Steel Nuts (Metric).
 16. ASTM A568/A568M - Standard Specification for Steel, Sheet, Carbon, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for.
 17. ASTM A572/A572M - Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.
 18. ASTM A992 - Standard Specification for Steel for Structural Shapes.
- C. American Welding Society:
1. AWS A2.4 - Standard Symbols for Welding, Brazing, and Nondestructive Examination.
 2. AWS D1.1 - Structural Welding Code - Steel.
- D. Research Council on Structural Connections:
1. RCSC - Specification for Structural Joints Using ASTM A325 or A490 Bolts.
- E. The Society for Protective Coatings (SSPC):
1. SSPC - Steel Structures Painting Manual.
 2. SSPC Paint 15 - Steel Joist Shop Paint.
 3. SSPC Paint 20 - Zinc-Rich Primers (Type I - Inorganic & Type II - Organic).
- F. Underwriters Laboratories Inc.:
1. UL - Fire Resistance Directory.

1.3. SUBMITTALS

- A. Submittals Procedures: Refer to submittal requirements.
- B. Fabrication Drawings:
1. Indicate profiles, sizes, spacing, location of structural members, openings, attachments and fasteners.
 2. Design and details of connections.
 3. Cambers and loads.
 4. Indicate welded connections with AWS A2.4 welding symbols. Indicate net weld lengths.

- C. Mill Test Reports: Submit indicating structural strength, and destructive and non-destructive test analysis.
- D. Manufacturer's Mill Certificate: Certify products meet the specified requirements.

1.4. QUALITY ASSURANCE (Equivalent Equal Acceptable)

- A. Fabricate structural steel members in accordance with AISC S303.
- B. Perform Work in accordance with AISC S303, Section 10.
- C. Maintain one copy of each document on site.

1.5. DELIVERY, STORAGE AND HANDLING

- A. Store materials to permit easy access for inspection and identification. Support steel members off ground. Protect steel members and packaged materials from corrosion and deterioration. Materials showing evidence of damage will be rejected and shall be immediately removed from the site.
- B. Do not store materials on structure in a manner that might cause distortion or damage to members or supporting structures. Repair or replace damaged materials or structures as directed.
- C. Do not handle structural steelwork until paint has thoroughly dried. Care shall be exercised to avoid abrasions and other damage.
- D. All fasteners and washers shall be delivered to the site, where they will be installed, in unopened containers.

PART 2 - PRODUCTS

2.1. MATERIALS (Equivalent Equal Acceptable)

- A. Manufacturer: Any recognized manufacturer having an official technical agreement to conformity with standards for the product.
- B. Structural Steel Members: ASTM A36/A36M, ASTM A242/A242M, ASTM A514/A514M, ASTM A529/A529M, ASTM A568/A568M, and/or ASTM A572/A572M, Grade 40.
- C. Structural Tubing: ASTM A500 and/or ASTM A501.
- D. Pipe: ASTM A53/A53M, Grade B.
- E. Shear Stud Connectors: ASTM A449. Forged steel, headed, and/or unfinished.
- F. Suspension Cable: Wire rope.
- G. Sag Rods: ASTM A36/A36M.
- H. Bolts, Nuts, and Washers: ASTM A307, ASTM A325M bolts, ASTM A449 bolts, ASTM A490M bolts, ASTM A563 nuts, and/or galvanized to ASTM A123/A123M A153/A153M for galvanized structural members.
- I. Anchor Bolts: ASTM A307 for embedded anchors; and high strength bolts for chemically and mechanically anchored anchors.

- J. Welding Materials: AWS D1.1; type required for materials being welded.
- K. Sliding Bearing Plates: Teflon coated.
- L. Grout: Non-shrink type, pre-mixed compound consisting of non-metallic aggregate, cement, water reducing and plasticizing additives, capable of developing minimum compressive strength of 48 MPa at 28 days.
- M. Shop and Touch-Up Primer: SSPC 15, Type 1, red oxide.
- N. Touch-Up Primer for Galvanized Surfaces: SSPC 20, type I: Inorganic or II: Organic.

2.2. FABRICATION (As Below Unless Agreed Otherwise With Employer)

A. General:

- 1. Fabrication to be performed in accordance with Chapter M of AISC "Specification for Structural Steel Buildings" and the Drawings and Specifications.
 - a. Assume all thermally cut edges are subject to substantial stresses.
 - b. Paragraph M4.6 shall be considered deleted from Chapter M.
 - c. The last sentence of paragraph M5.1 shall be deleted.
- 2. Provide holes and accessories required for securing other work to the work specified here.
- 3. Where thickness of material exceeds 7/8 inch or the diameter of hole, drill or ream holes after punching even when punching is allowed by referenced standards. Flame cut holes for fasteners are not acceptable.
- 4. Fabricate beams and girders with natural camber upward, unless otherwise shown or indicated on the Drawings.
- 5. Splice members only where indicated on Structural Drawings or where accepted by the Architect.
- 6. Remove burrs that would prevent solid seating of the connected parts.

B. Architecturally Exposed Steel

- 1. All members exposed to view in the completed structure shall be classified as "Architecturally Exposed Structural Steel".
- 2. Comply with the provisions of the AISC Code of Standard Practice for Steel Buildings and Bridges regarding architecturally exposed structural steel.
 - a. Abutting cross sectional configurations shall match.
 - b. Remove backing bars.
 - c. Remove weld runoff tabs and grind smooth
 - d. All surfaces and welds exposed to view shall be treated as finished surfaces.
- 3. Exposed Welds:
 - a. All exposed fillet welds shall be made smooth of uniform convex contour, radius and dimension for their full length; grind smooth, if welds were not made to this criteria.
 - b. All other exposed welds shall be milled or ground smooth and flush with the surfaces of the adjoining materials welded.
- 4. Weld show-through shall not be permitted.
- 5. Remove weld splatter on architecturally exposed steel.
- 6. All exposed corners shall be square and sharp, eased to a radius of 1/4 in.

C. Bolting, General:

- 1. Bolts shall be of a length that will extend not less than 1/4 in beyond the nuts unless noted otherwise.
- 2. Washers shall be used on Bolts. Use beveled washers where bolts bear on sloping surface.
- 3. Bolts shall be installed such that no threads occur in the shear plane.
- 4. Manufacturer's symbol and grade markings shall appear on all bolts and nuts.
- 5. Product containers must be marked so that correspondence with mill reports can be established.
- 6. Holes in column base-plates shall be no more than 1/8 inch larger than the nominal bolt size.

7. Circular and slotted holes shall be as per Specification for Structural Joints Using ASTM A325 or A490 Bolts.
 8. When bolt holes are subject to welding shrinkage stresses the holes shall be drilled.
- D. Unfinished Bolts and Anchor Bolts:
1. Install and tighten unfinished bolts in accordance with requirements for snug tightened bolts as defined in "Specification for Structural Joints Using ASTM A325 or A490 Bolts".
 2. Mutilate bolt threads for unfinished bolts to prevent the nuts from backing off.
- E. High-Strength Bolts:
1. Install high-strength threaded fasteners in accordance with RCSC "Specifications for Structural Joints using ASTM A 325 or A 490 Bolts". Contact surfaces of bolted parts shall as a minimum comply with the class A requirements.
 2. Unless otherwise noted, all connections are "slip critical (friction) type".
 3. Tighten nuts using Direct Tension Indicator. Calibrated wrench and "Turn of Nut" methods are not acceptable.
 4. When connection has bolts and welds, tighten bolts prior to welding with the exception that in moment connections the flange welds are completed prior to final tightening of high strength bolts.
 5. When already tensioned bolts have had their tension relaxed, either re-torque the bolts using a calibrated wrench or replace the [bolt and] tension indicator and re-tighten.
- F. Welding:
1. Welding shall be in accordance with AWS D1.1 "Structural Welding Code".
 - a. Contractor is responsible for selection of specific materials and procedures except as specifically noted in contract documents.
 - b. Connections have varying levels of restraint and thus necessary steps shall be taken by Contractor to control or accommodate the restraint.
 - c. Welding and fabrication procedures shall incorporate measures necessary to eliminate cracking. These measures shall include but are not limited to additional pre-heat, post-heat, or retarded cooling.
 - d. When selecting materials and procedures, consideration shall be given to the need for materials and procedures in excess of code requirements.
 - e. The need for pre-heat and other procedures are to be based on the actual chemistry and mechanical properties and not solely on the grade for which the steel was certified.
 - f. Weld variables shall be consistent with the recommendations of the electrode manufacturer.
 - g. Welding Procedure Specifications shall be readily available to all welders, inspectors, and Engineers.
 - h. Welding procedures shall incorporate low hydrogen practices.
 - i. Use stringer beads only (no weaving).
 2. No tack welds not incorporated into a weld will be allowed on the finished structure with the exception of backing plates that are not removed.
 3. All groove or butt welds shall be full penetration unless noted otherwise on the Drawings.
 4. Do not weld into column flange to column web intersection.
 5. Sequence the Work as necessary to accommodate testing.
 6. Remove-run-off tabs and backup plates and grind surfaces smooth as required for inspection or testing.
 7. At "special moment connection" or "eccentrically braced frame" connections:
 - a. Remove backing bars and apply reinforcing fillet weld per note J of figure 2.4 of AWS D1.1.
 - b. Remove weld runoff tabs and grind smooth.
 - c. Delete "...root and ..." from subsection 4.14.1.5 of AWS D1.1-94
 - d. Limit oscillation of FCAW electrodes to 3d, for $d \geq 3/32$ inches, and to 5d, for $d < 3/32$ inch (d = wire diameter).
 - e. Pay increased attention to uniform and adequate preheat.

- f. Maximum interpass temperature not to exceed 550 degrees F when notch toughness properties are specified.
 - g. Complete individual weld layers prior to applying portions of subsequent layers. Ends of interrupted passes to be staggered. Minimize starts and stops within body of the weld.
- 8. Splices of members in tension, that are made from ASTM A6 Group 4 of 5 rolled shapes, and or plates more than 2 inches thick shall be made in conformance with Section J1.7 of "Specification for Structural Steel Buildings ASD", 9th Edition.
- 9. Shear Studs: Install shear studs in accordance with the manufacturer's recommendations and AWS D1.1
- 10. Where tubes, pipes or other closed sections are exposed to the weather, provide seal welds where other specified welds do not provide a complete seal of the enclosed space.

G. Finishes of Architecturally Exposed Steel:

- 1. All surfaces of architecturally exposed structural steel members shall be uniform in appearance, including smoothness and texture, when viewed in direct sunlight at a distance of 10 feet, at angles of incidence 0 degree to 90 degree at completion of the following stages of work:
 - a. "Surface Preparation" and "Shop Prime Painting".
- 2. Surface Appearance: The initial condition of steel to be exposed in use shall conform to SSPC-V is 1 Rust Grade A. The exposed surfaces, edges and ends of all plates and other components shall be free of any surface defects including weld splatter, burrs, dents, gouges, occlusions, streak, ridges and recesses. Such defects may be repaired and surface restored with weld or other approved filler material and machining (milling, grinding or sanding) to match appearance, including smoothness and texture, of parent surface.
- 3. All surfaces to be grit blasted to SA 2.5 (Swedish Standards).

E. Shop Painting:

- 1. All structural steel exposed to the weather, classified as Architecturally Exposed Steel, or not completely concealed by interior finishes shall receive a shop coat of primer except as follows:
 - a. Steel in contact with concrete.
 - b. Contact surfaces of welded connections and areas within 4 in on each side of field welds.
 - c. Machined surfaces.
 - d. Contact surfaces of high-strength bolted connections.
 - e. Reinforcing steel.
- 2. The following surfaces shall be temporarily protected by a thin coating of varnish or lacquer:
 - a. Unpainted areas around field welds.
 - b. Steel around high strength bolts.
 - c. Machined surfaces.

2.3.FINISH (As Below Unless Agreed Otherwise With Employer)

- A. Prepare structural component surfaces in accordance with SSPC.
- B. Grit blast all surfaces to SA 2.5 (Swedish Standards).
- C. Shop prime structural steel members. Do not prime surfaces that will be fireproofed, field welded, in contact with concrete and high strength bolted.
- D. Galvanize structural steel members to ASTM A123/A123M. Furnish minimum 380 g/sq m galvanized coating.
- E. Apply an approved four coat protective paint system.

2.4. SOURCE QUALITY CONTROL AND TESTS (As Below Unless Agreed Otherwise With Employer)

- A. Testing and inspection of structural steelwork will be performed by the independent testing agency cost of which shall be borne by Contractor. Provide the Inspector with the following:
 - 1. A complete set of accepted "Submittals"
 - 2. Cutting lists, order sheets, material bills, and shipping bills
 - 3. Representative sample pieces as requested by the testing agency
 - 4. full and ample means and assistance for testing all material
 - 5. Access and facilities, including scaffolding, temporary work platforms, etc., for testing and inspection at all places where materials or components are stored or fabricated, and also in their erected position.
- B. Scheduling of Tests and Inspections
 - 1. The Contractor shall notify the Inspector in sufficient time prior to fabrication or erection work to allow testing and inspection without delaying the work.
 - 2. Shop welds will be inspected in the shop before the work is painted or shipped.
- C. Each person installing connections shall be assigned an identifying symbol or mark and all shop and field connections shall be so identified so that the Inspector can refer back to the person making the connection.
- D. Non-destructive Testing and Inspections
 - 1. As a minimum the inspector shall make all tests and inspections as required by the 1997 Uniform Building Code Inspector will make all the tests and inspections indicated in the Construction Documents.
 - 2. The Inspector shall make all verification tests and inspections as required by AWS D1.1 "Structural Welding Code".
 - 3. Do not reduce testing frequency unless permission is obtained from the Engineer.
 - 4. Inspector shall be present during all welding operations.
 - 5. Verify that welders are certified.
 - 6. Check materials, equipment and procedures. Verify meters on welding equipment are functioning and are accurate.
 - 7. Visual Inspection:
 - a. Visually inspect all welds.
 - b. Visual inspection of multi-pass welds to be continuous.
 - c. Visually inspect welds to Group 4 and 5 sections of at least 72 hours after completion of welding for the presence of cracks.
 - 8. Test Methods:
 - a. Butt welds will be tested using ultrasonic or radiographic test methods.
 - b. Butt welds to pipes and tubes to be tested using magnetic particle tests.
 - c. Use magnetic partial test methods for fillet welds and the supplement the testing requirements for butt welds.
 - d. At inspector's option dye penetrant testing, and resistance testing methods may be used in place of or to supplement magnetic particle testing.
 - e. For radiographic a double film technique will be used. One copy of each film will be sent to the Architect, the other will be retained by the Inspector.
 - f. In addition to the non-destructive testing specified other non-destructive test methods recognized by AWS D1.1 may be used at the Architects discretion and the results can be used to reject work under this contract.
 - 9. Frequency of non-destructive examination is to be as follows:
 - a. Full penetration butt welds: 100 percent.
 - b. Partial penetration butt welds with a leg length greater than 1/2 in: 20 percent min. ultrasonic or radiographic inspection.
 - c. Test 100 percent of partial penetration butt welds used in column splices.
 - d. Test 20 percent of total length of all welds joining web plates to flanges.

- e. Fillet and other welds not otherwise addressed - a minimum of 10 percent.
 - f. Selection of welds to be examined: Where there is a requirement for less than 100% examination the method of selection of welds to be examined is to be agreed with the Engineer before commencement of the work. If the Engineer does not provide more specific criteria inspectors will select the welds to be tested. The inspectors will chose specific weld so as to obtain results that are representative of the conditions in the structure. In addition inspectors will emphasize those locations that experience has shown are more likely to have problems.
 - g. On five percent of the full penetration butt welds as chosen by the inspector/Engineer, after removing, run-off tabs, grind the end of the weld sufficiently to allow determination of number and sizes of weld passes.
10. Testing of Base Metal: These provisions are in addition to other applicable requirements.
- a. The edges of material to be welded will be ultrasonically examined for evidence of laminations, inclusions or other discontinuities.
 - b. Ultrasonically test column flanges and webs at the location of all moment connections and brace connections. Test for a distance 3 inches around the location to be welded. The test procedure and acceptance criteria is defined by ASTM A898-91, "Standard Specification for Straight Beam Ultrasonic Examination of Rolled Steel Structural Shapes" Level I.
 - c. Base metal thicker than [1-1/2] inches, when subjected to through-thickness weld shrinkage strains, shall be ultrasonically inspected for discontinuities behind and within a distance of 3 inches of such welds after joint completion. Any material discontinuities shall be accepted or rejected on the basis of the defect rating in accordance with flaw severity, Class B criteria in Table 8.2 in AWS D1.1.
11. Where inspection reveals unacceptable defects:
- a. The extent of inspection will be increased as much as necessary to assure that the full extent of the defects in a joint has been found and to assure that the same defects are not present elsewhere.
 - b. As a minimum, examine two additional joints in the group represented by the joint. If the non-destructive examination of the two additional joints reveals unacceptable defects, examine each joint in the group.
- E. Take samples of all welding consumables and store in sealed containers.
- F. Tests of High Strength Bolts, Nuts and Washers:
- 1. The Inspector will make all tests and inspections of high strength bolt connections as required by RCSC "Specifications for Structural Joints Using ASTM A 325 or A 490 Bolts".
 - 2. Observe all Direct Tension Indicators to see if proper tightness was achieved.
 - 3. Confirm that the faying surfaces have been properly prepared before connections are assembled.
- G. Testing of End-Welded Studs:
- 1. End-welded studs shall be random sampled and tested from stock furnished to each project. Tests shall meet the requirements in Table 7.1 of AWS D1.1. The minimum number of tests of each required property shall be as follows:

Number of Pieces to Be Used from Identified Package	Number of Specimens
150 and less	1
151 to 280	2
281 to 500	3
501 to 1200	5
1201 to 3200	8
3201 to 10000	13
10001 and over	20

A minimum of three pieces from each lot shall be tested.

2. Production control testing shall be in accordance with AWS D1.1 Chapter 7.
3. As a minimum test, accordance with AWS D1.1 paragraph 7,8, [ten] percent of all welded studs.

H. Inspection Records

1. Make systematic record of all welds, including:
 - a. Location and type of weld.
 - b. Identification marks of welders.
 - c. List of defective welds.
 - d. Manner of correction of defects.
2. The Inspector will maintain a daily record of the work that has been inspected and its disposition. One copy of each of the report will be submitted to the Employer on a weekly basis. Test reports will be made on the form suggested in the AWS D1.1 "Structural Welding Code".

PART 3 - EXECUTION

3.1. EXAMINATION

- A. Refer to corresponding sections.

3.2. ERECTION

- A. Allow for erection loads, and for sufficient temporary bracing to maintain structure safe, plumb, and in alignment until completion of erection and installation of permanent bracing.
- B. Field weld components and shear studs as indicated on fabrication drawings.
- C. Field connect members with threaded fasteners; torque to required resistance tighten to snug tight for bearing type connections.
- D. Do not field cut or alter structural members without approval of the Engineer.
- E. After erection, prime welds, abrasions and surfaces not shop primed or galvanized, except surfaces to be in contact with concrete.
- F. Grout under base plates in accordance with Section 04065. Trowel grouted surface smooth, splay neatly to 45 degrees.

3.3. ERECTION TOLERANCES

- A. According to ASTM requirements and subject to the approval of the Engineer.
- B. Maximum Variation from Plumb: 6 mm per story, non-cumulative.
- C. Maximum Offset from Alignment: 6 mm.

3.4. FIELD QUALITY CONTROL

- A. Refer to the required testing and inspections, and subject to the conformity to ASTM requirements and subject to the approval of the Engineer.

2.8.3 STEEL STRUCTURE WITH METAL PANELS CLADDING

PART 1 - GENERAL

1.1. SUMMARY

- A. Section includes steel structure with metal panels cladding to roof and walls; protective treatment of steelwork; metal gutters and downspouts; related flashings and accessory components; concealed or exposed fasteners; standing seam or lapped seam.

1.2. REFERENCES (Equivalent Equal Acceptable)

- A. American Iron and Steel Institute:
 - 1. AISI SG-973 - Cold-Formed Steel Design Manual
- B. American Society of Civil Engineers:
 - 1. ASCE 7 - Minimum Design Loads for Buildings and Other Structures.
- C. ASTM International:
 - 1. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
 - 2. ASTM A666 - Standard Specification for Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
 - 3. ASTM A755/A755M - Standard Specification for Steel Sheet, Metallic Coated by the Hot-Dip Process and Pre-painted by the Coil-Coating Process for Exterior Exposed Building Products.
 - 4. ASTM A792/A792M - Standard Specification for Steel Sheet, 55% Aluminum-Zinc Alloy-Coated by the Hot-Dip Process.
 - 5. ASTM A924/A924M - Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process.
 - 6. ASTM D226 - Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing.
 - 7. ASTM D2178 - Standard Specification for Asphalt Glass Felt Used in Roofing and Waterproofing.
 - 8. ASTM D4397 - Standard Specification for Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications.
 - 9. ASTM D4586 - Standard Specification for Asphalt Roof Cement, Asbestos-Free.
 - 10. ASTM E283 - Standard Test Method for Determining the Rate of Air Leakage through Exterior Windows, Curtain Walls, and Doors under Specified Pressure Differences across the Specimen.
 - 11. ASTM E331 - Standard Test Method for Water Penetration of Exterior Windows, Curtain Walls, and Doors by Uniform Static Air Pressure Difference.
- D. Federal Specification Unit:
 - 1. FS TT-C-494 - Coating Compound, Bituminous, Solvent Type, Acid Resistant.
- E. National Roofing Contractors Association:
 - 1. NRCA - The NRCA Roofing and Waterproofing Manual.
- F. Sheet Metal and Air Conditioning Contractors:
 - 1. SMACNA - Architectural Sheet Metal Manual.
- G. Underwriters Laboratories Inc.:
 - 1. UL 580 - Tests for Uplift Resistance of Roof Assemblies.

1.3. DESCRIPTION OF WORK

- A. Steel Structure for the Construction of the Hangar:

1. The work covers the design, supply of all required materials, construction as per approved final detailed design, and maintenance of the hangar.
 2. The Contractor shall acquaint himself with the site and the drawings and shall take his own particulars to ensure the complete fabrication drawings, construction, installation and other requirements under the contract.
 3. The Contractor shall undertake and prepare all fabrication drawings relating to the works. The Contractor shall provide and submit to the Engineer all details and supporting data as required under the contract.
- B. Protective Treatment of Steelwork:
1. All structural steelwork shall be painted in accordance with the corresponding specifications.
- C. Metal Panel Cladding for the Hangar:
1. The work covers the supply, delivery, construction, commissioning and maintenance of metal panels cladding to the hangar.

1.4. SUBMITTALS

- A. Submittal Procedures: Refer to submittal procedures.
- B. Fabrication Drawings:
1. Indicate metal wall, roof and soffit panel profiles, jointing patterns, jointing details, fastening and/or welding methods, steel structure, flashings, gutters and downspouts, terminations and installation details.
- C. Product Data:
1. Submit data on metal types, finishes and characteristics.
 2. Submit color charts for finish selection.
- D. Samples:
1. Submit two samples 300 x 300 mm in size illustrating metal finish color.
- E. Manufacturer's Installation Instructions: Submit instructions including special procedures for roofing penetrations, gutters and downspouts, flashings and perimeter conditions requiring special attention.
- F. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.5. QUALITY ASSURANCE (*Equivalent Equal Acceptable*)

- A. Calculate structural properties of framing members in accordance with AISI SG-973.
- B. Perform Work in accordance with SMACNA Architectural Sheet Metal Manual and the NRCA Roofing and Waterproofing Manual.
- C. Perform work in accordance with the drawings and to the satisfaction of the Engineer.
- D. Maintain one copy of each document on site.

1.6. PRE-INSTALLATION MEETINGS

- A. Refer to relevant sections.
- B. Convene minimum one week prior to commencing work of this section.

1.7. DELIVERY, STORAGE AND HANDLING

- A. Refer to the requirements for transporting, handling, storing and protecting products.
- B. Stack material to prevent twisting, bending and abrasion, and to provide ventilation. Slope metal sheets to ensure drainage.
- C. Prevent contact with materials causing discoloration or staining.

1.8. FIELD MEASUREMENTS

- A. Verify field measurements prior to fabrication.

1.9. COORDINATION

- A. Refer to relevant sections.

PART 2 PRODUCTS (*Equivalent Equal Acceptable*)

2.1. MANUFACTURER

- A. Manufacturer: Any recognized manufacturer having an official technical agreement to conform with standards for the product.
- B. Furnish materials in accordance with the drawings and to Engineer's satisfaction.

2.2. STEEL STRUCTURES FOR THE HANGAR

- A. Weldable Structural Steels:
 - 1. Steel plates, bars and sections, shall be made by approved manufacturers and shall be in accordance with relevant French, British or American Standards.
 - 2. High yield steel shall be made by approved manufacturers and shall be in accordance with the relevant French British or United States Standards.
- B. Cold Rolled (If Required):
 - 1. Cold-rolled steel sections shall comply with the provisions of BS 2994 or shall be in accordance with the standards of the American Iron and Steel Institute or equivalent equal.
- C. Stamping or Marking:
 - 1. The steel is to be stamped or marked with a private mark for the purpose of identification as may be directed or approved by the Engineer.
- D. Bolts and Nuts:
 - 1. The heads of bolts shall be forged out of solid. The nuts and shanks of bolts shall be cleanly cut with standard threads and the nuts shall fit the bolts accurately and sufficiently tightly that they can just be screwed down by hand. Samples shall be submitted to and approved by the Engineer or his Representative before any bolts, nuts or washers are used in the Works.
 - 2. All bolts shall have hexagonal heads and nuts.
 - 3. Black bolts and nuts shall comply with the British or American Standards. All bolts, nuts and washers shall be galvanized to approved standards.
- E. Washers:
 - 1. All bolts and nuts shall be complete with washers with standard or taper washers to the approval of the Engineer or his Representative.

2. Flat washers shall be circular, of a diameter 2.5 times that of the bolt and of suitable thickness. Where bolt heads or nuts bear upon leveled surfaces they shall be provided with square taper washers of suitable thickness to provide a seating for the bolt head or nut square with the axis of the bolt.

F. In addition to what is stated above, steelwork shall be as specified in section 05120.

2.3. PROTECTIVE TREATMENT OF STEELWORK (*Equivalent Equal Acceptable*)

- A. Only paints of the highest quality shall be used in the Works. They shall be suitable for use in the climatic conditions pertaining at the Site and shall be delivered to the Site in the makers unopened containers. The materials for the complete coating system shall be supplied by an approved single specialist manufacturer.
- B. Steel structure shall receive an approved paint system after thorough preparation of the surfaces to be painted. The protective treatment and painting to steelwork shall be in accordance with the specifications, and mainly those described in Section 10 of the General technical Specifications as well as Section 2.10.3 of the present Particular Technical Specifications document.
- C. In addition to what is stated above, protective treatment of steel structure shall be in accordance with the corresponding specifications.

2.4. METAL PANELS (*Equivalent Equal Acceptable*)

A. Metal Roof and Wall Panels:

1. Panels for roof, walls and roof false ceilings shall be in painted galvanized steel roof and wall cladding, as produced by "Kirby", "Butler" or "Zamil", 0.5 mm thick minimum or similar approved.
Panels for doors shall be in painted galvanized steel cladding corrugated steel panels), as produced by "Kirby", "Butler" or "Zamil", 1.2 mm thick minimum or similar approved for the corrugated steel panels sandwiched by metal reinforcement, pertaining to the manually operated two-leaves painted metallic sliding door
2. Panels shall conform to ASTM A792 Grade 50 B, and shall be hot dip coated with a corrosion resistant Zinc/Aluminum alloy with 150 g/m².
3. The exterior exposed surface shall be coated with silicon modified polyester paint. The interior exposed surface shall be coated with polyester paint.
4. Panels are end lapped by extending one panel 100mm over the preceding one.
5. Panels shall have a suitable groove at the top of the edge rib so as to provide a siphon break to prevent water seepage by capillary action when overlapped.
6. Hoods in painted galvanized steel are to be factory manufactured to shapes indicated on the drawings.
7. All flashings and trims are to be factory manufactured to the profiles and shapes generally as indicated on the drawings. When these are not shown standard flashings and trims shall be supplied in accordance with the manufacturers' standard details. Flashings and trims where shown on the drawings, may be modified to suit manufacturers' standards but shall be approved before supply and incorporation in the works.
8. Main fasteners for sheeting shall be stainless steel self-tapping screws with stainless steel and neoprene washers. Side laps shall be secured as required by approved rivets. All materials for fixing shall be supplied by the sheeting supplier and shall be compatible with the cladding.
9. All flute fillers shall be performed to suit the sheet profile and are to be manufactured in foamed polyethylene or equal and approved.

2.5. CLADDING

- A. All cladding and associated work shall be supplied and installed by the Contractor or by a specialist cladding Sub-Contractor having the appropriate experience and qualifications, who shall

be responsible for the preparation of shop drawings, for supply and erection drawings and for the installation. Both sets of drawing shall be submitted to the Engineer for approval.

- B. Full coordination shall be undertaken with the supplier of structural steel work so that member spacing suits cladding requirements.
- C. The cladding supplier and erector shall guarantee a complete water tightness and weather tightness. Special attention shall be paid to end and/or side laps of cladding. Where required special sealant shall be utilized in conformity with the manufacturers' standard details. In particular where the roof slope is less than 5°, where required bitumastic sealer shall be incorporated in such laps in accordance with the sheeting manufacturer's recommendations.
- D. Care shall be taken in the storing and handling of cladding and ancillary items and no damaged cladding shall be incorporated into the works. The touch up on site of any damaged coatings will only be allowed when specifically approved by the Engineer or his representative. If approved, the coating used shall be that supplied by the sheeting manufacturer to match precisely any factory applied surfacing.
- E. Notwithstanding the specified maintenance requirements for the works, the specialist cladding Sub-Contractor shall guarantee the weather tightness of the whole of the cladded elements for a period of five years calculated from the time that the works are substantially complete. The Contractor will be deemed to have included for the provision of such guarantee in his rates.
- F. The cost of supplying and erecting all flashings and trims are deemed to be included in the Contractor's unit rates.

2.6. GUTTERS AND DOWN SPOUTS

- A. The cladding Sub-Contractor shall design, supply and install gutters and down pipes to convey the surface water from top of structure.
- B. The materials used shall be compatible with those used in the panels cladding to the steel structure. Adequate support systems shall be included.
- C. Gutters and down pipes shall be designed in accordance with British Standard Code of practice 308 or to an equivalent standard. The maximum intensity of rainfall shall be considered as 125mm per hour for design purposes. All calculations and drawings for rainwater goods shall be approved by the Engineer prior to the manufacture of such goods commencing.
- D. Minimum thickness of gutter material shall be 0.5mm, and of pipe material shall be 5mm.

2.7. FABRICATION

- A. Form sections shape as indicated on the drawings, accurate in size, square and free from distortion or defects.
- B. Fabricate flashing, gutters and other metal components from same material as metal panels and with exposed metal surface finish as exposed face of metal panels.
- C. Form pieces in single length sheets.
- D. Fabricate gutters to profile and size as per approved design.
- E. Fabricate downspouts to profile and size as per approved design.
- F. Fabricate supplementary accessories in profile and size to suit gutters and downspouts (for large gutter girth):

1. Anchorage Devices: Recommended by fabricator complying with SMACNA.
2. Gutter Supports: Brackets, straps, or Spikes and ferrules.
3. Downspout Supports: Brackets, or straps.

PART 3 EXECUTION

3.1. EXAMINATION

- A. Refer to the corresponding sections related to the verification of existing conditions before starting work.
- B. Structural Framing Substrate:
 1. Verify primary and secondary framing members are installed and fastened, properly aligned and sloped.
 2. Verify damaged shop coatings are repaired with touch up paint.
- C. Verify roof openings, curbs, pipes, sleeves, ducts, or vents through roof are solidly set, reglets are in place, and nailing strips located.
- D. Verify roofing termination and base flashings are in place, sealed and secure.
- E. Verify insulation is installed and ready for roof application.

3.2. PREPARATION

- A. Metal Deck Substrate:
 1. Fill knot holes and surface cracks with latex filler.
- B. Back paint concealed metal surfaces and surfaces in contact with dissimilar metals with protective backing paint to minimum dry film thickness of 0.4 mm.

3.3. INSTALLATION - STEEL STRUCTURES

- A. General: The fabrication and erection of the structural steelwork shall be carried out in accordance with French British or US practice and shall be to the approval of the Engineer.
- B. Rolling Margin: The rolling margin of plates, sections and bars shall be in accordance with the relevant Standards. All materials outside those margins will be liable to rejection.
- C. Steel Tapes: Steel tapes used for marking out the work shall be calibrated at a temperature of 20°C.
- D. Bolt Holes:
 1. All bolt holes in members built up by welding shall be drilled after welding has been completed.
 2. Holes which are drilled through two or more separable parts shall have all burrs removed after separating the parts.
- E. Notches: The ends of all joists, beams and girders shall be truly square. Where required, the joist flanges shall be neatly cut away or notched where necessary, the notches being kept as small as possible and well radiused.

F. Joints in Steelwork:

1. The shop welding of structural steelwork profiles to form the required length of any element indicated in the Drawings will be allowed only with the express permission of the Engineer.
2. Machine welding shall be carried out with approved machines sufficiently supervised by qualified operators. Hand welding shall be executed in an efficient manner by fully qualified workmen equipped with plant suitable for the purpose.
3. The manipulators and sequence of welding shall be suitable for the work, and the Engineer's approval to the same shall be obtained before welding is commenced.
4. Surfaces to be welded shall be properly prepared beforehand and kept clean and free from extraneous matter during welding.
5. All welds shall be finished full and made with the proper number of runs, the welds being kept free of slag intrusions, and all adhering slag shall be carefully removed from the exposed surfaces immediately after each run.
6. The Engineer will make spot checks on the soundness of the parent metal and welds by ultrasonic testing or gamma rays, and the Contractor or sub-contractor shall, at his own cost, provide all equipment necessary for such tests and shall cut out and remove any portion of the steelwork which the Engineer or his Representative shall decide is defective.
7. All weld metal shall be of suitable steel, relative to the parent metal of the structure. Continuous electrodes for machine welding shall be to the approval of the Engineer.

G. Site Welding: No site welding shall be carried out without the specific approval of the Engineer.

H. Temporary Erection:

1. If required by the Engineer, the component parts of structures shall be temporarily erected at the Contractor's or sub-contractor's works for inspection, and shall only be dismantled when approval has been given by the Engineer.
2. The Contractor or sub-contractor shall, without charge, provide all temporary flooring, staging, bolts and nuts and everything necessary to be used during erection at his works.

I. Erection Marks: Before any steelwork leaves the Contractor's or sub-contractor's works it shall be suitably marked in accordance with the approved working drawing and according to an approved working plan. Erection marks shall be clearly painted on work and all members weighing over 5 tons shall have the weight marked thereon.

J. Protection: All steelwork shall be efficiently and sufficiently protected against damage in transit to Site from any cause whatever.

K. Accuracy of Setting Out: The Contractor or sub-contractor shall be responsible for the correct lining and leveling of all steelwork on Site and for the accurate plumbing of stanchions. The Contractor shall afford to the Engineer or his Representative all necessary assistance in checking the setting out of the works and interpreting any marks made by the Contractor for the purpose of setting out Base lines and bench mark levels shall be agreed with the Engineer or his Representative.

L. Erection: The Contractor or sub-contractor shall supply all labors and materials, plant, staging, haulage, storage and all services and things necessary for the erection of the steel superstructures complete.

M. Liners: In cases where, owing to difficulties of erection, some clearance may be essential this clearance shall be a minimum allowance and fitting liners shall be provided to make good, but where practicable, such liners shall be avoided.

- N. Storage of Steelwork: Steelwork which is to be stored prior to erection shall be stacked clear of the ground with packing between parts. The stacks shall be arranged so as to avoid the accumulation of dirt and water on the surfaces and if cover is provided it shall be ventilated to the satisfaction of the Engineer.
- O. Stability of Structures:
1. The Contractor or sub-contractor shall be responsible for the stability of the structures at all stages of their erection on Site and shall take all necessary measures, by the addition of temporary bracing and guys, to ensure adequate resistance to wind.
 2. The Contractor or sub-contractor shall furnish to the Engineer five copies of a layout drawing showing the position of all cranes and other erection equipment, clearly indicating all erection loads imposed on foundations, and the Contractor shall be responsible for spreading the imposed loads to the approval of the Engineer should this be found necessary.
- P. In addition to what is stated above, installation of steel structure shall be in accordance with "Structural Steel"

3.4. INSTALLATION - PROTECTIVE TREATMENT OF STEELWORK

- A. Surface Preparation and Painting of Steel:
1. Treatment and Preparation:
 - a. All treatment of steelwork is to be in accordance with BS 4232 and BS 5493 or equivalent.
 - b. Steel shall be free from corrosion, moisture, grease, oil, and the like, before blasting or any paint coating is applied. Workshop conditions, storage, transport and erection of painted materials shall be in accordance with BS 5493 to ensure that they are in a satisfactory condition when erected. Paint on all steel shall be fully cured before transportation to Site. No surface shall be left bare for marking purposes. When bolts are utilized they shall be prepared and painted to the works specification as soon as possible to prevent rust staining.
 - c. Facilities shall be made available for inspection of the work at all stages by the paint manufacturer's representative and by the Engineer or his Representative.
 2. Prefabrication Surface Treatment at Works: All steel, including the plates, stiffeners, cleats, gussets, and the like, shall be cleaned by abrasive blasting in accordance with the BS standards, Second Quality minimum (Swedish Standard SIS 055900 - 1967, Sa 2½). Any laminations or surface defects exposed by blasting shall be chipped off and ground and then re-blasted, before priming commences. When blasting is completed residual grit and dust shall be removed by vacuum cleaning or careful brushing. Painting shall be carried out only under such climatic conditions as approved by the paint manufacturer and the Engineer or his Representative. The surface temperature of the steel shall be at least 3°C above the dew point during the blasting and painting operations.
 3. Prefabricated Priming at Works: Within 2 hours of blast cleaning or before re-rusting occurs, one zinc rich epoxy primer coat shall be applied by airless spray in accordance with the manufacturer's instructions, color grey.
 4. Fabrication at Works: When the coat of primer is fully dry, all steelwork shall be fabricated as required and necessary.
 5. Post-Fabrication Surface Treatment at Works: Weld areas shall be fully cleaned of all slag weld splatter, together with any flux and other surface contaminants, as per BS 5493. Any oil, grease or dirt shall be removed by washing with detergent and rinsing with clean water, as necessary. Advice shall be sought from the paint manufacturer if it is necessary to remove zinc salts.

6. Identification Marks: All identification marks for steel work erection marked on the fabrication works shall be applied using materials compatible with the specified coating system.
 7. Finishing Treatment on Site after Erection: Any oil, grease, dirt and other contaminants shall be removed by washing with detergent and rinsing with fresh water as necessary. Final welds be prepared and damaged areas repaired by blast-cleaning to BS Second Quality as necessary and the original protection re-established with zinc silicate primer according to the manufacturer's instructions.
 8. The protective treatment and painting to steelwork shall be in accordance with the specifications, and mainly those described in Section 10 of the General technical Specifications as well as Section 2.10.3 of the present Particular Technical Specifications document.
- B. Surface Preparation and Galvanizing of Steel (If Required):
1. General: All galvanizing of steelwork is to be in accordance with BS 729. All steel is to be free from heavy corrosion. Workshop conditions, storage, transport and erection of all galvanized steelwork shall be such as to ensure that it is in a satisfactory condition when erected. No surface shall be left bare for making purposes. Facilities must be made available for inspection of work at all stages by the Engineer or his representative, but this will not absolve the Contractor from carrying out work in accordance with this Specification.
 2. Treatment and Preparation: All steel is to be free from contamination which will not be removed by pickling, e.g. paint, oil, grease, welding, slag etc. Wherever possible steel should not be susceptible to strain age-hardening (See BS 729 Appendix E). Water soluble paints may be used for temporary identification permanent identification marks should be deeply punched or embossed. Adequate clearances should be allowed on mating surfaces such as hinges. Provision to be made for all necessary filling, venting and draining.
 3. Galvanizing:
 - a. Hot dip galvanizing shall be to BS 729; Pt 1, including all nuts, bolts, washers, brackets, etc. to be used in subsequent assembly. The minimum coating weight shall be 610 gm/m² for plate less than 2 mm thick, and 900 gm/m² for other steelwork.
 - b. All nuts separately galvanized and other steel tapped to receive bolts are to be tapped over size after galvanizing and the threads oiled.
 4. Post-Galvanizing Treatment at Works: After thorough cleaning and drying, all small areas of damage caused by welding, cutting, etc., shall be renovated:
 - a. either by the use of low melting point rods or powders made specifically for this purpose, or
 - b. by a minimum of two coats of good quality 92% zinc rich two-pack epoxy paint applied in accordance with BS 5493 and the manufacturer's recommendations to give a minimum dry film thickness at least equal to the galvanized coating.
 5. Painting Galvanized Steelwork (If Required): Galvanized steel articles shall be painted as requested in Section 10 of the General technical Specifications as well as Section 2.10.3 (Protective treatment schedule to steelwork) of the present Particular Technical Specifications document
 6. Sherardized Nuts, Bolts and Washers: Zinc coated in accordance with the requirements of BS 4921; with Class 1 coating thickness.
- C. Plastic Coating of Steelwork: If required specification shall be submitted by the Contractor for approval.
- D. Vitreous Enameling of Steelwork: If required specification shall be submitted by the Contractor for approval.

- E. In addition to what is stated above, protective treatment of steelwork shall be subject to the approval of the Engineer.

3.5. INSTALLATION - METAL PANELS CLADDING

- A. Install Work in accordance with the approved shop drawings and to the satisfaction of the Engineer.
- B. Secure panels to substrate.
- C. Adjust panels for uniform joints.

3.6. INSTALLATION - GUTTERS AND DOWNSPOUTS

- A. Built-In Gutters:
 - 1. Secure gutter lining to substrate with cleats spaced minimum 910 mm on center, unless otherwise stated, along edges of gutters.
 - 2. Longitudinal joints not acceptable.
 - 3. At roof edges, extend gutter lining under metal roofing 150 mm minimum and terminate in 19 mm folded edge secured by cleats. Hook lower end of roofing into lock strip to form 19 mm wide loose-lock seam.
- B. Secure gutters and downspouts in place using concealed fasteners.
- C. Slope gutters minimum 20 mm/m (2%).
- D. Seal gutters watertight. Seal joint of gutter to drain.
- E. Connect downspouts to rain water system, unless otherwise shown on drawings. Seal connection watertight.
- F. Set splash pans or pads under downspouts. Secure in place.

3.7. PROTECTION OF INSTALLED CONSTRUCTION

- A. Refer to the sections related to the procedure of installed construction.
- B. Do not permit traffic over unprotected surfaces.

2.9 SECTION 9: FLOOR, WALL AND CEILING FINISHES

2.9.1 RENDER

Rendering shall be executed mainly at the locations as shown on the drawings or directed by the Engineer.

Exterior rendering (if required) shall be Ordinary Portland Cement (OPC type I) with waterproofing admixture.

The biofilter system reinforced concrete structure (fair face concrete) shall not be rendered.

Note:

An intruding “rain water strip” or groove shall be executed in the render or concrete at the locations as directed by the Engineer and mainly at protruding elements and parapets, in order to prevent the surface movement of rain water on the walls, and allow it to drop.

2.10 SECTION 10: PAINTING AND DECORATING

2.10.1 RENDER, PAINTING, WATERPROOFING AND PROTECTIVE COATINGS

Rendering, painting, waterproofing and protective coatings shall be executed mainly at the locations as shown on the drawings or directed by the Engineer. The general guidelines could be summarized as follows.

Painting, waterproofing and protective coatings shall be the best quality available in Lebanon. The colour will be selected by the Engineer. They shall be applied according to the manufacturer's recommendations.

The PVC liner as specified in sections 4.6 and 11.6.2 of the General Technical Specifications shall not be foreseen for the protection of concrete surfaces in contact with sewage or H₂S)

The protection of concrete surfaces in contact with sewage or H₂S (such as interior surfaces of man-holes) shall be foreseen by the quality of the concrete itself (Sulfate Resistant Portland Cement (SRPC Sulphate type V)), waterproofing admixture, cover, as well as a coal tar epoxy coating (thickness 300 microns, etc.).

Coating and painting shall be executed mainly at the locations as shown on the drawings or directed by the Engineer. The general guidelines could be summarized as follows.

Note: High quality exterior decorative coloured white cement coating (plaster type "monocouche" with a thickness around 8 to 10mm):

The product should be applied in accordance with the manufacturer's instructions to produce an excellent coating compatible with the site conditions.

The product should have the following characteristics:

- Be of high quality
- Have a thickness around 8 to 10mm
- Be specified for the exterior applications and be compatible with the site conditions
- Provide an excellent protection against the aggressivity due to tough and aggressive weather conditions, to UV
- Provide a stability of colours
- Provide high elasticity, ductility, hardness and abrasion resistance.

Note:

An intruding "rain water strip" or groove shall be executed in the render or concrete at the locations as directed by the Engineer and mainly at protruding elements and parapets, in order to prevent the surface movement of rain water on the walls, and allow it to drop.

2.10.2 PROTECTION OF EXTERIOR CONCRETE SURFACE

The protection of exterior concrete surface below ground level shall be according to Section 4.2.4 of the General Specifications "Protection of exterior concrete surface" as described herebelow.

The exterior surfaces of all manholes and structures above the water table shall be coated with an approved tar compound applied in two coats.

The Contractor shall produce documentary evidence that the tar compound proposed to be used is suitable for the intend purpose and has been successfully used in similar installations. Surfaces to be protected shall be dry and thoroughly cleaned from dust and loose material. Projections shall be re-

moved and all defects shall be adequately repaired and made good before the application of the compound. The tar compound shall be applied in accordance with the manufacturer's instructions and recommendations and as directed or approved by the Engineer.

2.10.3 PROTECTIVE TREATMENT SCHEDULE TO STEELWORK

Protective treatment to steelwork shall be in accordance with the following schedule.

Untreated Steelwork		Nominal DFT (microns)
MAIN PRIMER	1 coat	
Zinc Rich Epoxy Primer	ZINC RICH EPOXY PRIMER	50
MAIN PRIMER (Spraying)	1 coat	75/
2-pack Epoxy Zinc Phosphate	ZINC PHOSPHATE PRIMER	100
INTERMEDIATE COAT (Spraying)	1 coat	
2-pack Epoxy Undercoat	HI-BUILD	100
FINISH COAT (Brushing or Spraying)	2 coats	
2-pack Polyurethane Gloss Finish	SPECIAL FINISH	70

The total dry film thickness shall not be less than 300 microns

Galvanised Steelwork		Nominal DFT (microns)
Degrease using cleansing degreasing agents	G 500 Cleansing Solution	-
Lightly abrade		-
RE-TREATMENT (Brushing)	1 coat	-
Mordant Solution	MORDANT WASH	

(Paint application shall not proceed until this check indicates, by the development of a black conversion coating, that the entire area is suitably prepared to receive paint)

INTERMEDIATE COAT (Spraying)	1 coat	125
2-pack Epoxy Undercoat	HI-BUILD	
FINISH COAT (Brushing or Spraying)	2 coats	
2-pack Polyurethane Gloss Finish	SPECIAL FINISH	70

The total dry film thickness, excluding zinc, shall not be less than 150 microns

Such primers, undercoats and finishing coats shall be resistant to industrial gases, hydrogen sulphide fumes, high humidity and exposure to tropical sun

Damaged paintwork shall be blast cleaned if bare metal is exposed or corrosion is present. If the first coat is intact the surface shall be prepared by power wire brushing. The prepared surface shall be protected with the full paint system.

However, concerning Type B application specified hereabove (steelwork, which is in contact with sewage, or is in close proximity to sewage, or is buried in the ground): zinc rich epoxy primer and heavy-duty epoxy coal tar shall be applied, with the required primer coats, undercoats and final coats and required thickness, according to the instructions of the manufacturer and as approved by the Employer's Representative.

2.11 SECTION 11: ROOFING AND WATERPROOFING

No particular specifications.

2.12 SECTION 15: ELECTRICAL WORKS

2.12.1 INTRODUCTION

The general specifications are mainly described in "Section 15: Electrical Works".

The particular specifications are described hereafter.

2.12.2 GENERAL

The electrical works shall include all required electrical equipment, installation and electrical supply, as shown on the drawings, in the specifications and as directed by the Engineer.

The works shall also include stand-by power for all equipment required to maintain the plant in a safe and steady manner and making it possible to restart the plant after a power black-out.

The Contractor shall be responsible for undertaking the necessary complementary detailed design including the corresponding detailed technical specifications, technical data and execution drawings and shop drawings pertaining to the electrical works, as well as all details deemed necessary (including, among others, cable ducts, cable trays, openings in the structures for the passage of the cables, etc.)

2.12.3 GENERAL SPECIFICATION

All electrical equipment shall operate without restriction on continuous full-load conditions under the following climatic conditions as the minimum requirement:

- Max. temperature: 50 °C
- Min. temperature: -5 °C
- Relative humidity: 100 %

All panels and enclosures shall be coloured as approved by the Engineer.

2.12.4 POWER FACTOR CORRECTION

Power factor correction equipment shall be provided on all systems to ensure that a minimum power factor of 0.9 is achieved at the Point of Common Coupling

The system shall be designed to cope with the harmonic voltages generated by the various variable drives by the use of series connected inductors. These shall be sized to ensure that the power factor device resonant frequency does not correspond to a harmonic frequency.

2.12.5 MOTORS

Small motors up to a rated power of 5 kW shall be protected by temperature compensated thermal overloads and can be started DOL.

Motors with a rated power above 5 kW shall be protected by electronic protection relays providing hot and cold thermal overload, earth fault and single phase protection and shall be started by soft starters.

2.12.6 PANELS

Panels shall be type 2B (and not type 4B as stated in the General specifications).

2.13 MECHANICAL WORKS

2.13.1 GENERAL

The specifications stated in Section 5 of the General Specifications are not applicable. They shall be substituted by Section 18 of the General Specifications "Plumbing, Drainage and Mechanical Works".

The Particular Specifications of the equipment are stated in the schedule of equipment.

In addition, the specifications stated in Section 16 of the General Specifications "Mechanical Works" shall only be applicable for only some items not described elsewhere. In case on non compatibility, the requirements of Section 18 shall prevail over those of Section 16.

2.13.2 DRAINAGE AND WATER PIPES

Drain pipes for biofilter shall be of High Density Polyethylene (HDPE) having special characteristics for leachate/wastewater drainage and having high resistance in order to support the loads laid upon them. Physical properties for HDPE shall be conform to the ISO and DIN standards.

The Contractor shall submit for approval, the manufacturer's documents confirming their compatibility with the conditions which they will be exposed to.

Pipes thickness and characteristics shall correspond to PE-100 .

Water pipes shall be of High Density Polyethylene (HDPE) having high resistance in order to support the loads laid upon them. Physical properties for HDPE shall be conform to the ISO and DIN standards.

The Contractor shall submit for approval, the manufacturer's documents confirming their compatibility with the conditions which they will be exposed to.

Pipes thickness and characteristics shall correspond to PE-100 .

Slopes shall be conform to the drawings or as directed by the Engineer.

2.14 SECTION 19: MISCELLANEOUS

2.14.1 CONCEPTUAL DESIGN OF THE VENTILATION/AIR EXTRACTION/COLLECTION SYSTEM

2.14.1.1 Description of the sorting hangar – existing situation

The sorting hangar could be described as follows:

- The sorting hangar dimensions are around: Length 50 m x Width 30 m x a height varying between 5.4m on the sides and 8.4m in the centre. The calculated volume is around 10,350 m³.
- The sorting hangar is closed from all sides. The exterior sides (i.e. the 3 sides adjacent to the outside) are composed of (from top to bottom):
 - o From the ground level up to a height of 3.1m above ground level: 3.1m reinforced concrete wall (excluding part of the western exterior side, along a length of 25m) which is composed of a blockwork wall
 - o A 40cm open band/strip, from a height of 3.1m up to a height of 3.5m
 - o From the top of the band/strip till the top of the hangar: A metal panel
- Access ways are provided for this hangar by the means of one roller shutter door of dimensions: 4.5m (width) x 4.7m (height) on the waste reception side, and two roller shutter doors of dimensions: 4.9m (width) x 4.5m (height) and 5.1m (width) x 4.5m (height) on the opposite side.



Figure 3 : View of the sorting hangar accessways

The interior side, separating the sorting and composting hangars, is also composed of a combination of blockworks and metal panels, separated by a reinforced concrete stone border as shown in the following photo.



Figure 4: View from the interior of the composting hangar and the wall separating the sorting and composting hangars

2.14.1.2 Description of the composting hangar – existing situation

The composting hangar could be described as follows:

- The composting hangar dimensions are around Length 60 m x Width 30 m x a height varying between 5.4m on the sides and 8.4m in the centre. The calculated volume is around 12,420 m³.
- The composting hangar is closed from the side of the sorting hangar and open from all the remaining (i.e. exterior) sides. The exterior sides (i.e. adjacent to the outside) are composed of (from top to bottom):
 - o A 20cm stone/blockwork border at ground level
 - o From the border and up to a height of 3.5m: Open space.
 - o From the level +3.5m up till the top of the hangar: A metal panel
- Two access ways of dimensions 5.4m (height) x 4.5m (width) are provided for this hangar as shown in the schematic figure herebelow. At the location of these access ways, no blockworks are erected and the metal panels are cut to allow the rectangular shaping of the access ways.

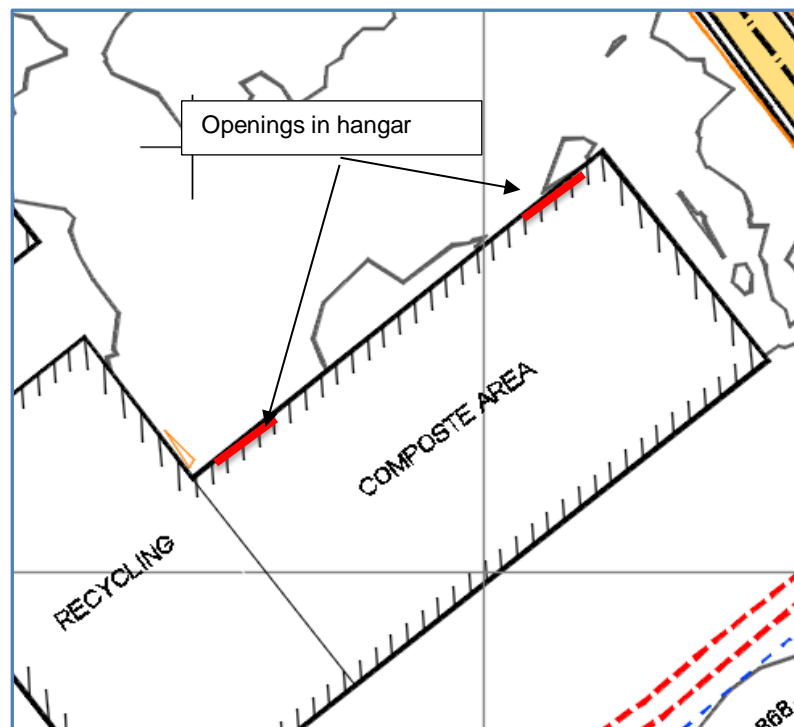


Figure 5: View of the composting hangar opening for accessways



Figure 6: View of the composting hangar façade



Figure 7: View of the composting hangar access way

2.14.1.3 Required ventilation and air extraction from the sorting hangar

The following measures shall be considered for the ventilation and air extraction from the sorting hangar:

- The open band/strip of height around 40cm shall be preserved to ensure proper provision of natural aeration
- Two stainless steel (EN 1.4301 / AISI 304) axial extraction fans will be installed at the separation of the sorting and composting hangar in order to extract air from the sorting hangar and inject it into the composting hangar to serve as fresh air.
- The fans should be equipped with shutters to prevent backflow and infiltration of air from the composting hangar to the sorting hangar.
- The unit flow of each fan will be 18,000 m³/h, resulting in a total flow of 36,000 m³/h, which is the equivalent of the volume of air extracted from the composting hangar as explained hereafter. Hence, the resulting calculated renewal rate in the sorting hangar will be around 3.47 times per hour.
- The fans shall be heavy duty resistant to corrosion
- The maximal allowable noise level generated by the fans shall be under 75 dB at 1m. The fans shall be equipped with all the necessary measures for sound attenuation in order to remain under the maximal allowed noise levels, including but not limited to sound enclosure and measures for room sound attenuation.
- The sorting hangar shall have adequate louvers on the side walls to ensure the required exchange rate.

The following table corresponds to the sorting hangar fan power and airflow characteristics

Table 1: Characteristics of sorting hangar axial fan system

	Units	Values
Adopted number of fans	Unit	2 duty, 1 backup fan stored in stock
Extracted unit airflow per fan	m ³ /h	18,000
Adopted extraction fan static pressure	Pa	600
Estimated required extraction fan power	kW	7.5

Materials of fans

- Impeller: Alue 231
- Housing: Stainless Steel 1.4301
- The fans shall be heavy duty resistant to corrosion



Figure 8: View of the interior of the composting hangar

2.14.1.4 Required ventilation and air extraction from the composting hangar

The following measures shall be requested for the ventilation and air extraction from the composting hangar:

- The existing stone/blockwork border laid at ground level shall be removed
- The open spaces between ground level and the metal panels shall be closed by a blockwork wall to be rendered from the interior side, and provided with reinforced concrete tie beams and columns
- The accessways previously described shall be closed by the means of a manually operated two-leaves painted metallic sliding doors of dimensions, height 5.4m x width 4.5m composed of two 1.2mm corrugated steel panels sandwiched by metal reinforcement
- Galvanized steel ducts with support fixtures on the metal structures, will be installed along the composting hangars to allow fouled air extraction from various locations within the hangar
- Two stainless steel (EN 1.4301 / AISI 304) centrifugal extraction fans will be installed at the biofilter odor management system to extract fouled air from the composting hangar
- The unit flow of each fan will be 20,000 m³/h, resulting in a total flow of 40,000 m³/h. Hence, the resulting calculated renewal rate in the sorting hangar will be around 3.22 times per hour
- The fans shall be heavy duty resistant to corrosion
- The maximal allowable noise level generated by the fans shall be under 75 dB at 1m. The fans shall be equipped with all the necessary measures for sound attenuation in order to remain under the maximal allowed noise levels.

- Fans shall be equipped with Variable Frequency Drive (VFD) for operation at variable speeds and frequencies, and shall be equipped with shock absorbers and compensators

The verification of the design and sizing of collection ducts, and the calculation of the associated pressure drop, is required to be carried out. The extraction fan static pressure shall be verified to account for the pressure drop of the whole system, corresponding to the pressure drop in the composting hangar extraction system as well as in the biofilter system.

	Units	Values
Adopted number of fans	Units	2 (1 duty and 1 standby)
Extracted unit airflow per fan	m ³ /h	40,000
Adopted extraction fan static pressure	Pa	2,000
Calculated required extraction fan power	kW	37
Length of duct system in composting hangar	m	135
Size of duct	mm	Varying between 350 and 1,100mm

Materials of the fans:

- Impeller: Alue 231
- Housing: Stainless Steel 1.4301
- The fans shall be heavy duty resistant to corrosion

2.15 BIOFILTER ODOR CONTROL SYSTEM

This section mainly concerns the biofilter odor control system.

2.16 INTRODUCTION

The Biofilter shall be used to treat the extracted air from the enclosed hall where fermentation of organic material takes place in composting (fermentation) hall (hangar).

The Biofilter shall be an open top Biofilter. The slab and three sides of the Biofilter shall be in concrete adequately protected to allow front end loader operation on top of it as described herebelow, and the remaining side shall be connected to the prescrubber unit.

2.17 BIOFILTRATION

Due to its process-integrated biological regeneration the biofilter technique is an effective method for odor elimination and treatment of low concentration or undefined exhaust air streams. This advantage is realized due to the natural reactions of the biological degradation of contaminants. It takes place at:

- ambient temperature
- neutral pH and normal pressure
- produced no problematic final products
- is CO₂ neutral

2.18 PRINCIPLE OF OPERATION

Technically a biofilter is a bulk layer of organic dampened material through which the exhaust air flows slowly through to be treated. It naturally contains a microflora that increases under appropriate environmental conditions and adapts to the degraded exhaust components.

The exhaust components are separated by sorption at the filter material and dissolved in the contained moisture film while it flows through the organic bed. The dissolved air components reach into the micro-organism cells by diffusion and osmosis and degrade it to ecologically non-relevant compounds.

The functionality of the biofilter essentially depends on the sorption capacity of the biofilter and the biological activity of its bioflora. Their properties and activities are determined not only by material properties, but also by the exhaust parameters incoming from the prescrubber unit. These include:

- The temperature of the water vapor-saturated air (ideally between 15 and 40 °C)
- The water vapor saturation of the air to be treated (close to the saturation point)
- The concentrations of pH-related exhaust components (as low as possible)
- The concentration of dust and liquid aerosols (such as fat, resin or lubricant), (as low as possible)
- The content of toxic or accumulating exhaust components (e.g. heavy metals) in negligible concentrations

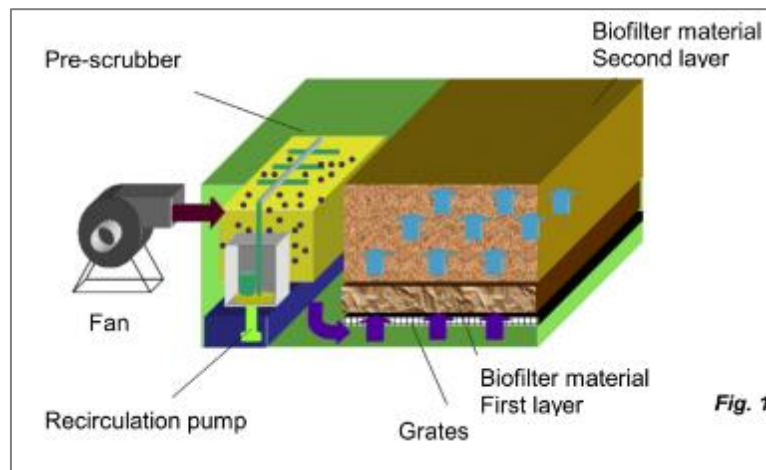


Figure 9 : Principles of Biofiltration

2.19 BIOFILTER MATERIAL

A mixture of organic material is used as a substrate for the bacterial flora that is well structured and does not collapse. The pressure drop remains constant over a long time.

In the biofilter, two layers shall be used with different filter media. In fact:

- The first layer (corresponding to a coarse biomass) should guarantee an optimal distribution of the incoming exhaust air and direct it homogeneously onto the overlying filter layer. The bottom layer is used to start rotting fine particles without condensations occurring. The material used for the base shall be cracked root wood. This is characterized by a high mechanical support function as well as a large surface area and thus additional habitat for the degrading microorganisms.



Figure 10 : To the left: Root Wood. To the right: Pine bark with wooden parts

- The second layer (corresponding to a fine biomass) is a special mixture of organic material. It serves as a support substrate and adds missing nutrients for microorganisms into the raw air. At the same time, this mixture is also sufficiently resistant to biodegradation and ensures a constant flow. Compaction and channeling in the filter bed can thus be further prevented.

The filter mixture shall provide a very low-pressure loss and high-water storage capacity. It shall also have a high buffering capacity and can thus maintain a pH value optimum for the microorganisms.

With correct operation, biofilter odor control systems can provide a very long lifetime. Under optimum conditions, operating times and lifetime of the media shall be between 3 and 6 years, with a minimum required of at least 4 years, without any material change.

In the case of the present project, the biofilter media shall be made of a combination of:

- A distribution layer composed of pre-fermented root wood (broken and fibrous root timber mainly from root stocks), of height around 0.4m, composed of pine wood (in a proportion of around 85%), and foliage tress (in a proportion of around 15%)
- A main layer composed of pre-fermented pine bark with wooden pieces pine bark, of height around 1.2m, composed of pine bark (in a proportion of around 60%) originating from fresh untreated materials from saw mill, and wood partly sticking to the bark (in a proportion of around 40%). The material should offer low pressure drop, efficient and constant pollution degradation of fouled air quality, and a capacity to accommodate for fluctuations in humidity. Pine bark with wood fraction acts as an efficient buffer, keeping an optimal pH in the filter medium. Without slacking a constant streaming (without channeling) shall be provided.

A sample of characteristics of biofilter media is attached in the annexes to the present report.

The extracted air, conveyed by ducts from the composting hangar towards the biofilter system, will be released underneath the media distribution. To this end a PVC grid support system of height 0.6m for the supporting of the biomass media and optimizing the distribution of air in the media shall be foreseen to be installed.

This system consists of grating with a high load carrying capacity as well as corresponding supports in lengths varying between 30cm to 100cm. the size pf the grating apertures shall be chosen and justified by the Contractor in order to:

- Prevent relatively smaller cover or filling material from falling through the holes
- Give the floor a large ventilation area, thus guaranteeing high air permeability

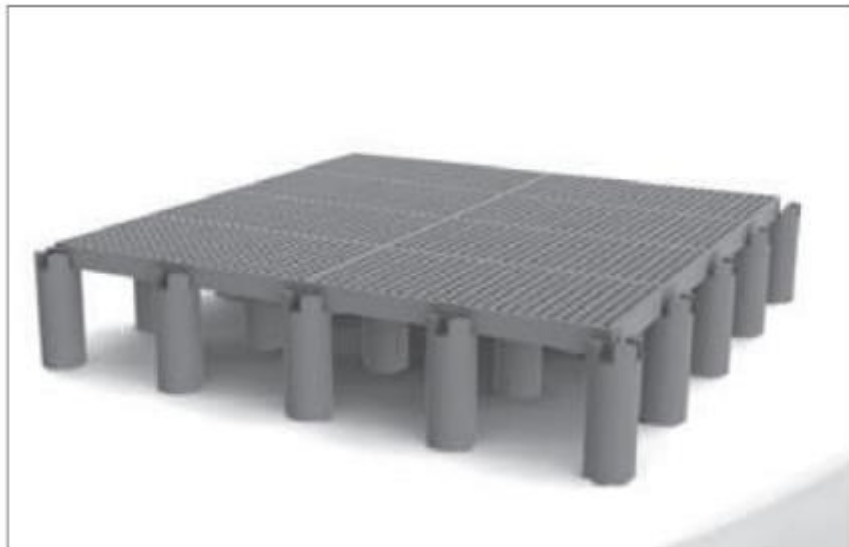


Figure 11: View of the PVC grid system

2.20 COMPONENTS OF THE SYSTEM

2.20.1 MATERIALS

2.20.1.1 Prescrubber and inside of biofilter materials

The prescrubber housing, the circuit line, the distribution channel, and all parts that are exposed to the exhaust air or the wash water (packing, gratings, etc.) shall be made of corrosion-resistant plastics. This material shall be characterized by high dimensional and chemical resistance as well as a high longevity.

The plastic is handcrafted from high quality polyester resins using glass fibre mats, glass fabrics and fleeces. The walls are made of a sandwich construction with a PU foam core. As a result, a high dimensional stability with minimal weight is achieved. At the same time, this wall structure serves as an insulator, whereby the condensate formation in the marginal zone of the filter material is avoided.

The prefabricated parts shall be easily assembled into a finished biofilter. Due to its modular design, the flexible biofiltration system can be expanded at a later phase as need be.

The inside of the biofilter and the washer shall also be equipped with an FRP protective coating against the chemicals. The outer skin shall be pigmented and interspersed with UV absorbers. Hence, the scrubber housing will be permanently protected.

2.20.1.2 Biofilter outer walls and slab materials

The outer walls of the biofilter system exposed to the outside (i.e. with the exception of the side connecting to the prescrubber) will be composed of:

- Cast-in-place reinforced concrete walls, using High Sulphate Resistant Cement to ASTM C150, Type V, 30 MPa tested on cylinder (38 MPa on cube).
- Provided with a protective coating on the internal surfaces (coal tar epoxy coating in 2 layers, total thickness 400 microns minimum);

The underground part of the walls will also be provided with:

- Bituminous coating layers for external surface (2 layers)

The wall footings will also be provided with:

- Bituminous coating layers for external surfaces (2 layers)
- 10cm layer of blinding concrete under the wall footings, cast-in-place plain using ordinary Portland cement to ASTM C150, Type I, 16 MPa on cylinder.

The wall footings will also be laid on the following two layers (from top to bottom):

- A 40cm thick minimum well graded base course layer (CBR 70%),
- A 60cm thick minimum well graded subbase course layer (CBR 50%),

The bottom slab of the complete biofilter system (i.e. biofilter, under prescrubber and under centrifugal fans) will be composed of (from top to bottom):

- Cast-in-place reinforced concrete walls, using High Sulphate Resistant Cement to ASTM C150, Type V, 30 MPa on cylinder.
- Provided with a protective coating on the internal surfaces (coal tar epoxy coating in 2 layers, total thickness 400 microns minimum);
- A damp proof membrane above the base course layer

The bottom slab will be laid on the following two layers (from top to bottom):

- A 40cm thick minimum well graded base course layer (CBR 70%),
- A 30cm thick minimum well graded subbase course layer (CBR 50%),

2.20.1.3 Miscellaneous civil works required for the execution of the complete biofilter system

These include:

- Site preparation and clearance, shall include removing and disposal of vegetation, undergrowth, bushes, hedges, trees, debris, trash and the like, disconnecting and sealing services (as applicable) and excavation of the top superficial soil layer
- Eventual soil replacement of unsuitable soil material

2.20.2 PRE-SCRUBBER

The purpose of the pre-scrubber is to achieve an optimum preconditioning of the exhaust air (i.e. setting the humidity of exhaust air to more than 95% prior to entering the biofilter media). Herewith the gas flow is set to the operating parameters necessary for the successful occurrence of microbiologic treatment in the biofilter media bed.

In addition, the dust and dirt must be removed from gases to prevent fouling of the carrier material and clogging of the biofilter material.

A chemical pre-treatment of exhaust air is required to ensure an optimum pH value in the liquid film or constant ambient conditions for the bacterial flora.

Both these measures should be realized in the prescrubber unit.

In order to effectively compensate load peaks in the exhaust stream and thus ensure high safety reserves, the recirculating wash water in the pre-scrubber is also used as a buffer and in order to achieve constant conditions for the microorganisms in the biofilter.

The prescrubber should respect the following requirements:

The following table shows the main conceptual design criteria for the sizing of the prescrubber unit/system:

	Units	Values
Airflow capacity of extraction fans conveying air to the system	m ³ /h	40,000
Reagent to be used		Sulfuric acid (H ₂ SO ₄)
Dimensions of the prescrubber (internal dimensions)	L x l x h	1.6m x 10.1m x 2.2m

The prescrubber concept is similar to that of the packed chemical scrubbing tower generally used in WWTPs. The system will be equipped with:

- Packing material: made of Polypropylene (PP), with a surface area between 90-100 m²/m³ and a free volume between 90 and 100%. Two packing beds of dimensions 1.6 x 1.4 x 1.2m (W x H x L) shall be provided in the prescrubber.
- Droplet separator
- Recirculation pump
- Recirculation pipe with pressure gauge and spraying nozzles
- Measuring equipment
- Level control for the pump sump (including overflow and drainage)
- Dry-run protection for the pump
- All internal piping

Note:

- It is to be noted that all dimensions provided in the specifications and shown on the drawings submitted herein, represent minimum criteria/volume to be fulfilled by the Contractor, are subject to the approval of the Engineer, and are subject to ensure the performance requirements stated herewith in this document, and depending on the manufacturer's specifications.
- Any addition to this system (including dimensions, equipment, structures, works, etc.) shall be justified by the Contractor, and be subject to the approval of the Engineer. Any cost related thereto shall be deemed to be included in the BOQ item "*Construction, installation, testing and commissioning of the complete biofilter system including the various components described in the various sections of these Tender Documents (and mainly the Particular Technical Specifications)*" and be borne by the Contractor.

2.20.3 RECIRCULATED WASH WATER

The wash water is constantly circulated in the pre-scrubber. The pump sucks the scrubbing liquid out of the scrubber sump and discharges it through the circuit line to the nozzle. There the spiral full cone nozzles spray the washing water constantly over the packed bed. It trickles through the packing and brings the exhaust air stream to the operating conditions specified above.

One backup recirculation pump shall be provided in stock and stored in the administration building/workshop.

2.20.4 RECIRCULATION PUMP

An extremely robust and corrosion resistant plastic vertical chemical pump is used as a recirculating pump. All wetted parts are tailored to the specific requirements of the partly aggressive or abrasive wash water. At the same time, the exhaust contaminants and the accompanying reagents, which are converted into the liquid phase, are considered.

Submersible pumps with dry erected engines should be used. These pumps are bolted on specially designed pump suction boxes, which are positioned directly on the scrubber housing.

2.20.5 PROVISION OF WATER TO THE PRESCRUBBER SUMP

The main facility water tank (connected to the public water supply grid) shall be equipped with pumps, pipes and accessories in order to pump water to a foreseen plastic water tank to be installed near the biofilter system.

This latter tank shall be executed and completely equipped with its piping, valves and accessories. It shall be executed on an elevated support to allow gravity connection to the prescrubber sump in order to be recirculated to the packing of the biofilter media.

2.20.6 PACKING

Due to their large active surface, which is wetted by water, the packing has the task to saturate the exhaust air. Simultaneously, the transfer of pollutants into the washing liquid is increased.

The used packing should respect a ratio of around 90-100 m² surface per m³ package available. Because of the special design of the packing (open frame, large active surface) many small washing liquid drops are split and reformed. During the process, the droplet surface is constantly renewed and can therefore absorb more pollutants.

2.20.7 MIST ELIMINATOR

Arranged behind each packed bed is a mist eliminator. It has the task to separate the entrained washing liquid droplets from the air stream. The used eliminators are characterized by a high degree of separation with low pressure drop and low risk of clogging.

2.20.8 SYSTEM CONTROL TECHNOLOGY

In principle, pre-scrubber shall be equipped with the following measuring and control devices:

- Level control in the washing water sump with automatic fresh water supply
- Dry run protection for circulation pump
- Pressure gauge for monitoring inlet pressure of the nozzle
- Sump heater with thermostat in the case of frost danger and to avoid sump freezing in winter times, and cold temperatures and during shut down times

In addition, the following control elements are available:

- pH control in the case of dosing of acids or bases

2.20.9 DOSING STATION

Due to the equipping of the pre-scrubber with a dosing station, it is possible to set a pH value for the wash water. Thereby air pollutants such as ammonia or hydrogen sulfide can be washed out in front of the biofilter in case of a high load. Thus, acidification of the biofilter can be avoided.

In case of dosing of acids (sulfuric acid) or alkaline (caustic soda) (sulfuric acid in the present project in light of the fact that in composting plants, the gas most commonly emitted in peak concentrations is ammonia, the concentration of which can be abated by chemical scrubbing with sulfuric acid), accordingly dimensioned dosing pumps are used. In general, these are magnet-operated diaphragm pumps. The wetted materials are adapted to the used chemicals.

The dosing pumps are driven by the generated signal from the pH measurement.



Figure 12 : Typical Biofilter



Figure 13 : Biofilter in Bar Elias designed by Libanconsult AGM within a similar study

The dosing station of acid ($\text{H}_2\text{SO}_4 < 76\%$) will be equipped with:

- Dosing pump built in prescrubber housing
- Suction and dosing line (10m each)
- pH probes
- Measuring and control devices

One backup chemical dosing pump shall be provided in stock and stored in the administration building/workshop.

2.20.10 BIOFILTER SYSTEM

The main design criteria for the optimum sizing of the biofilter bed system is the residence/contact time of the foul air in the media. According to literature, residence times used in conventional biofilter systems are in the range of 30 to 60 seconds.

The residence time adopted in the present project, shall be 37 seconds minimum, subject to ensure the performance requirements stated herewith in this document, and depending on the manufacturer's specifications.

The surface overflow rate (air velocity in the media) usually ranges between 100 and 160 m³/m².h depending on the manufacturer's specifications and will be set in this project to around 150 m³/m².h in order to ensure the performance requirements stated herewith in this document.

	Units	Values
Airflow capacity of extraction fans conveying air to the system	m ³ /h	40,000
Adopted sizes of biofilter (internal dimensions)	L x l (m x m)	26 x 10 = 260
Height of biofilter media	m	1.6
Height of biofilter walls	m	2.2
Actual media volume	m ³	416
Calculated empty bed residence/contact time	s	37
Actual calculated surface loading rate	m ³ /m ² .h	153.8

The bottom of the biofilter bed shall be adequately sloped (ensuring a slope < 0.2%) and a drainage pit installed (complete with its drainage piping accessories) to convey the percolated liquid out of the biofilter and towards the leachate collection tank.

The extremity of the outlet drain pipe conveying the percolated liquid from the drainage pit to the leachate collection tank shall be elevated around 5cm above the top of the drainage pit.

A bed access opening shall be foreseen in the body of the biofilter structure to allow filling and inspection of the media bed. It shall be closed by timber planks in steel profile and can be chosen according to local requirements by the Contractor and approved by the Engineer.

Note:

- It is to be noted that all dimensions provided in the specifications and shown on the drawings submitted herein, represent minimum criteria/volume to be fulfilled by the Contractor, are subject to the approval of the Engineer, and are subject to ensure the performance requirements stated herewith in this document, and depending on the manufacturer's specifications.
- Any addition to this system (including dimensions, equipment, structures, works, etc.) shall be justified by the Contractor, and be subject to the approval of the Engineer. Any cost related thereto shall be deemed to be included in the BOQ item "*Construction, installation, testing and commissioning of the complete biofilter system including the various components described in the various sections of these Tender Documents (and*

mainly the Particular Technical Specifications)” and be borne by the Contractor.

2.21 REQUIRED INCOMING AIR POLLUTION LOADS AND CONCENTRATIONS

The following table shows the maximal allowed pollutant concentrations in the inlet air, the foreseen treatment efficiency (%) of the system as well as the expected guaranteed concentrations in the treated air discharged at the outlet of the biofilter system in two cases of operation:

- Case 1: When the prescrubber system, equipped with overhead sprinkling/humidification system, is injecting water onto the packing media
- Case 2: When the prescrubber system, equipped with overhead sprinkling/humidification system, is also injecting chemicals (sulfuric acid) onto the packing media, such as in the case of peak ammonia loads

According to mail it looks like it will reach the same concentrations in outlet since chemicals are used only as peak provision

CASE 1 – When the prescrubber system, equipped with overhead sprinkling/humidification system, is injecting water onto the packing media			
Parameter	Maximal acceptable air <u>inlet</u> concentrations	Expected guaranteed treatment efficiency (%)	Maximal guaranteed discharged <u>outlet</u> air concentration
H ₂ S	< 5 mg/m ³	> 68%	< 1.6 mg/m ³
RSH (Mercaptans)	< 2 mg/m ³	> 50%	< 1 mg/m ³
NH ₃ (ammoniac)	< 5 mg/m ³	> 84%	< 0.76 mg/m ³

CASE 2 – When the prescrubber system, equipped with overhead sprinkling/humidification system, is also injecting chemicals (sulfuric acid) onto the packing media, such as in the case of peak ammonia loads			
Parameter	Maximal acceptable air <u>inlet</u> concentrations	Expected guaranteed treatment efficiency (%)	Maximal guaranteed discharged <u>outlet</u> air concentration
H ₂ S	< 5 mg/m ³	> 68%	< 1.6 mg/m ³
RSH (Mercaptans)	< 2 mg/m ³	> 50%	< 1 mg/m ³
NH ₃ (ammoniac)	< 40 mg/m ³	> 98%	< 0.76 mg/m ³

2.22 MISCELLANEOUS NOTES TO BE TAKEN INTO ACCOUNT

2.22.1 MISCELLANEOUS TECHNICAL DETAILS

- The Contractor shall provide in his offer provisions for fumigation for the biofilter media before transport to Lebanon and the project area including addition of 0.7 Kg/m^3 of urea (at 46%), as well as composting, overcasting and post-fermentation of the material for 4-5 weeks.
- Local control panels shall be installed for the biofilter system as well as for the axial extraction fans. The control panel shall be conveniently located to give fingertip management of all machine functions. All associated electrical works including power supply, electrical panels, cables, cable protection, earthing, necessary for the execution and operation of the biofilter odor treatment system and its various associated equipment and accessories shall be executed including:
 - o The works necessary for the connection of the biofilter system to the local control panel to be installed
 - o The works necessary for the connection of the axial fans extraction system to the local control panel to be installed
 - o The works necessary for the connection of the two aforementioned local control panels to the main control panel distribution board located in the administration building. The cable section will be minimum $3 \times 35 \text{ mm}^2 + 16 \text{ mm}^2$
- **It is to be noted that all dimensions provided in the specifications and shown on the drawings submitted herein, represent minimum criteria/volume to be fulfilled by the Contractor, are subject to the approval of the Engineer, and are subject to ensure the performance requirements stated herewith in this document, and depending on the manufacturer's specifications.**
- **Any addition to this system (including dimensions, equipment, structures, works, etc.) shall be justified by the Contractor, and be subject to the approval of the Engineer. Any cost related thereto shall be deemed to be included in the BOQ item "*Construction, installation, testing and commissioning of the complete biofilter system including the various components described in the various sections of these Tender Documents (and mainly the Particular Technical Specifications)*" and be borne by the Contractor.**
- The water supply networks, equipment and accessories required in this project shall be executed notably:
 - o The equipping of the main facility water tank (connected to the public water supply grid) with pumps, pipes and accessories in order to pump water to a foreseen plastic water tank to be constructed near the biofilter system.
 - o The execution of this foreseen plastic water tank near the biofilter system, on an elevated support to ensure gravity feeding
 - o The equipping of this latter tank with its piping, valves and accessories to allow gravity connection to the prescrubber sump
- The drainage networks, manholes, equipment and accessories required in this project shall be executed notably:
 - o The execution of a drainage pit at the bottom of the biofilter bed to convey the percolated liquid out of the biofilter and towards a collection manhole to be executed near the biofilter
 - o This pit will be equipped with a submersible pump, with piping and accessories to allow the pumping of the drained liquid towards the leachate collection tank.
- A 1-month supply of sulfuric acid (locally available material) should be ensured during operation to sustain proper functioning of the biofilter and prescrubber

2.22.2 MISCELLANEOUS NOTES AND QUALITY CONTROL NOTES

- The Contractor shall provide bills of lading and equipment specifications showing that the odor control system meets the technical requirements presented in the various sections of this report
- The Contractor shall provide the results of the quality control and quality assurance tests. In addition, the Contractor shall perform conformance tests, as described herebelow, demonstrating that the odor control system will meet the technical requirements presented in the various sections of this report.
- The odor control system must be supplied with a handbook for its usage and maintenance, a workshop manual and parts catalogue. English and Arabic (if available) copy from each manual must be delivered.

2.23 TESTING AND COMMISSIONING

2.23.1 TESTING

- The Contractor shall verify that the odor control system will be able to change the air in the enclosed composting hangar hall at the rate required in the specifications, and that the odor control system functions according to the manufacturer's specifications, and technical requirements presented in the various sections of this report
- The Contractor shall perform an analysis of the efficiency of the odor control system ensuring the discharge of outlet air is conform to the values specified in the tables hereabove.
- The Contractor shall perform a smoke test for joint integrity and to prove the efficiency of the air extraction and air distribution throughout the biofilter prior to the filling of the media. Smoke testing shall be carried out also in the sorting and composting hangars for the same purpose and in the aim to verify the air circulation and efficiency of air extraction.
- Testing shall be performed in the presence of the Employer or the Engineer.

2.23.2 COMMISSIONING

- The Contractor shall perform a Commissioning Test of the odor control system which shall be controlled by a Control Panel, and shall function for the duration of the Commissioning Period without damage to the equipment or breakdowns.

The Manufacturer shall provide a minimum 1-year warrantee on the odor control system against manufacturer's defects. Should the odor control system fail to function, the Contractor shall be required to repair the odor control system at no cost to the Employer.

3. ANNEX 1: SAFETY, HEALTH AND ENVIRONMENTAL REGULATIONS

Refer to Volume 1 of these Tender Documents.