Section 4

Sewer Testing
4.1 General

Sewers and ancillary works shall be tested and inspected for watertightness to prevent infiltration and exfiltration and to ensure the pipes are laid correctly according to the designed straightness and grade. The testing of the sewers and ancillary works before backfill will facilitate the replacement of any identified faulty pipes and joints. The testing of the sewers and ancillary works after backfill will reveal the leakages caused by the displacement of joints and subsequent damage. The testing shall be supervised by consultants and their testing certificates issued by the consultants shall be submitted to the Commission before final approval.

The tests that are required to be conducted are listed as follows:

I) Before Backfill

a) Gravity Sewer:
   i) Exfiltration Test (either low pressure air or water tests).
   ii) Check for straightness, obstruction and grade.

b) Force Main:
   i) Exfiltration Test (when required).
   ii) High pressure water test.
   iii) High pressure leakage test (following high pressure water test).
   iv) Check for straightness, obstruction and grade.

c) Manhole and others:
   i) Visual inspection.
   ii) Watertightness test (when required).

To prevent movement of the sewer, embedment material shall be placed around and over the sewer prior to testing. The section of the joints above spring line shall be exposed.

For pipe or part that is made of material that will deteriorate under the sun, the exposed parts of the pipe shall be shielded from direct exposure to the sun during testing.

The concrete used for supporting the pipe or resisting thrust shall be cured for at least seven days prior to testing.
II) After Backfill

Gravity Sewer:

i) Exfiltration Test (either low pressure air or water tests).

ii) Infiltration Test (when required).

iii) CCTV Test (when required).

Before and after any test, the sewer pipeline to be tested shall be clean, which shall be flushed clean when necessary. Any leaks or defects identified from any test shall be located and repaired. After testing has been completed, the cleaned sewer shall be plugged at open ends to prevent dirt or soil from getting into the sewer.

4.2 Testing of Gravity Sewers

The tests of gravity sewers are generally conducted to ensure there is no leaks, damages, or laying errors.

An exfiltration test, which can be either a low pressure air test or a water test shall be performed on the sewer before any concrete pipe encasement or backfill. After backfilling, an exfiltration test is required again on the sewer laid. In addition, an infiltration test shall be conducted if:

a) required by the Commission.
b) detected high groundwater table.

When infiltration has been confirmed by the infiltration test, light and mirror method or CCTV may be used to isolate the locations of leaks. If a CCTV inspection is conducted, a video and written record of the CCTV inspection shall be provided to the Commission no later than 7 days after the inspection.

For gravity sewers, the sewer length to be tested shall be the length between manholes or proposed manhole locations. The test length for water test may be shorter where the gradient is so steep as to cause too high a head at the downstream end. The pressure head on the sewer being tested shall not be less than 2 m above pipe crown at the upstream end and shall not be more than 7 m above pipe crown at the downstream end.

When desired, the air and water tests may be undertaken on shorter lengths of the laid sewer before backfill. This is to prevent any faulty joint to go unnoticed until it is revealed by a test on the complete length, which will be more costly and time consuming to rectify the defects. Testing of shorter lengths may also be necessary where it is required to
backfill the sewer to surface level quickly. This early backfill may be encountered when there is wet weather, traffic crossings or site safety requirements.

In every stage of the works, frequent tests of straightness and obstruction shall be conducted, when required, to ensure there is no line obstruction and the straightness or grade is correct.

### 4.3 Testing of Forced Mains

For pressure sewers, the normal tests during the sewer laying may include, where required, the low pressure air or water exfiltration tests on short individual sections. These low pressure air or water exfiltration tests are conducted, when required, to ensure that the joints are watertight.

As in gravity sewers, the force mains should be checked to ensure the straightness is correct and to ensure no obstruction in the force mains. Also, force main is required to be tested for its mechanical stability through the high pressure water test. Its watertightness shall be tested through high pressure exfiltration test. Before conducting these high pressure tests, the sewer support and thrust block shall be allowed to develop the sufficient strength. In addition, cautions shall be taken when dealing with high pressure.

Where required, a CCTV inspection should be performed on the pipeline after backfilling the trench. If a CCTV inspection is performed, a video and written record of the CCTV inspection shall be provided to the Commission no later than 7 days after the inspection.

For the high pressure water test, the test length will depend on:

a) the length which can be isolated effectively, i.e. suitable anchorage for temporary end closures.
b) the time permitted to leave the trench open without backfill taking considerations of weather, safety, traffic etc.
c) the location of permanent anchorages.
d) the maximum volume of water available to fill the pipeline.
e) the requirement to have the pressure at the highest point not less than 0.8 times the pressure at the lowest point.

After taking the above considerations, initially a maximum of 300 m length of pipe shall be laid and tested to verify that pipe laying practices are to an acceptable standard. The maximum lengths for subsequent tests may be progressively increased, as determined by the authorised inspection person, but shall not exceed 1500 m.
4.4 Testing of Manhole and Other Ancillaries

Manhole and other ancillaries shall be constructed in such a way that no appreciable amount of infiltration or exfiltration will occur. When the manhole and other ancillaries are constructed in an effective manner, visual inspection is normally sufficient. However, manholes and other ancillaries suspected of very poor workmanship shall be tested with exfiltration test before backfill or concrete surrounded.

Connections between sewer and manholes shall be constructed with extended cast-in-site concrete base and surround over the top of the rocker pipe in accordance to the standard drawing attached.

Drop manholes shall be constructed in such a way that no appreciable amount of blockage will occur with construction details as in the standard drawings which provide for proper pipe outlets and proper sizing of drop pipes.

A visual inspection is required on all the external and internal sections of each manhole before backfill. Particular attention shall be given to:

a) the slope of benching.
b) joints to pipes.
c) transitions at entry and exits.
d) joints in the structure.
e) quality of concrete finish.
f) watertightness of manhole cover and surround.

The internal surfaces of manholes shall be inspected visually for sources of infiltration after backfill and stabilisation of groundwater table. Manhole covers and surrounds shall be checked for leakage of surface water.

4.5 Low Pressure Air Test

4.5.1 General

Low pressure air test is one of the two sewer exfiltration tests recommended for sewer testing. The air test is quicker to conduct than the water test. Furthermore, no large quantity of water needed to be disposed off after the test. This test provides a quick mean for checking any damage pipe or joints. Sometimes the test is conducted on a short length to prevent damage pipe or joints from passing without noticed until the final sewer test, which could be more costly and time consuming to rectify. However, these tests on the shorter length should not replace the final test.
4.5.2 Procedure for Testing

a) Seal the open ends, including sideline ends, using approved plugs. Strut the plugs to prevent movement. Provide temporary bracing where necessary to prevent pipeline movement during testing. (One of the end plugs will require a connection point to permit injection of air).

b) Connect a hand or motorised pump to the pressure injection line at the end plug. Pressurise the test length at a slow and constant rate.

c) Use dial pressure gauges to measure pressure. Apply an air pressure of:
   i) 30 kPa for vitrified clay and reinforced concrete pipelines.
   ii) 50 kPa for all other pipelines.
   (Two gauges in series shall be used so that the accuracy of one gauge can be confirmed by the other. The dial gauges shall be able to be read to an accuracy of ± 0.1 kPa).

d) Wait five minutes for air pressure to stabilise due to temperature absorption into pipe wall and other effects. Adjust the pressure to the required test pressure during this period.

e) Check for leaks at plugs and test apparatus. Release the air pressure where leakage occurs. Make necessary repairs and adjustments of apparatus to prevent leakages. Repressurise the sewer pipeline in accordance with the preceding steps again.

f) Start the test and record the pressure loss for the test duration after the final gauge adjustment to the test pressure. Conduct the test for the test duration given in Table 4.1.

<table>
<thead>
<tr>
<th>Pipeline Nominal Size</th>
<th>Test Duration (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>2</td>
</tr>
<tr>
<td>225</td>
<td>4</td>
</tr>
<tr>
<td>300</td>
<td>6</td>
</tr>
<tr>
<td>375</td>
<td>8</td>
</tr>
<tr>
<td>450</td>
<td>11</td>
</tr>
<tr>
<td>525</td>
<td>14</td>
</tr>
<tr>
<td>600</td>
<td>17</td>
</tr>
</tbody>
</table>
g) Pass the test if the pressure loss over the test duration does not exceed:

i) 7 kPa for vitrified clay and reinforced concrete pipes
ii) 2 kPa for all other pipes

4.5.3 Procedures for Handling Air Test Failure

I) Before Backfill

a) Readjust the pipe pressure to the specified test pressure and examine for leakage by pouring a solution of soft soap and water over the exposed joints if the test fail.

b) Repair leaks and repeat testing where leaks are found at joints.

c) Where leaks are not found at joints, move the plug, the one that is not used to exert air pressure, along the pipeline to isolate lengths with leakage. Uncover pipe barrels in the isolated lengths where leakage in pipe barrels is suspected. Replace leaking pipe lengths and repeat testing.

d) Conduct low pressure water testing to verify that the air test was not erroneous where the test length fails the air test but no source of leakage can be identified.

II) After Backfilling

a) Move the plug up from the other end along the sewer pipeline to isolate the lengths that fail the air test.

b) Exhume the failed length of pipeline and replace pipe lengths.

c) Repeat the air test.

d) Conduct water testing to check that the air test was not erroneous when failed lengths could not be isolated using the air test.

e) Use CCTV, when required or available, to identify the leakage if the fail section can not be isolated by the air test or water test.

4.6 Low Pressure Water Test

4.6.1 General

The low pressure water test is commonly used for checking the watertightness of the joints and the integrity of the sewer pipes. Unlike the high pressure water test, this test can not be used to check the mechanical strength of the sewer pipe. Compared with low pressure air test, this test requires more time to set up the test. Also, the water used for the test
require disposal in an appropriate manner. However, this test will show the location of the leaks more clearly than the low pressure air test.

4.6.2 Procedure

a) Seal the open ends, including sideline ends, using approved plugs. Strut the plugs to prevent movement. Provide temporary bracing where necessary to prevent sewer movement during testing.

b) Establish appropriate arrangements involving a standpipe to apply the water head at the upstream end.

Acceptable arrangements include:

i) temporarily fitting a 90° bend to the upstream end, which should then be connected with a vertical riser of straight pipe to used as a standpipe.

ii) sealing the upstream end with a plug which has a connection point for a hose, which can be connected to a tube acting as a standpipe.

d) Fill in water from the upstream end. Ensure water head is not less than 2 m above pipe crown at the upstream end and not greater than 7 m above pipe crown at the downstream end. Shorten the test length if the sewer gradient is so steep as to cause these water head requirements not to be met.

e) Fill the sewer slowly to the required head and bleed air from behind the upstream plugs.

(Air may be released by slightly loosening the plug and pushing in a piece of wire between the seal and the pipe.)

f) Maintain the water head for two hours. Top up the water as required.

g) Check for leakage at the plugs and the test apparatus during the pressurising period and the constant pressure holding period. Release the water pressure if leakage occurs. Make the necessary repairs and adjustments before repressurising again.

h) Commence the test immediately after the last adjustment of water head in the preceding two hours period.

i) Add water to maintain the starting water head every 5 minutes during the test period of 30 minutes. Record the total amount of water required for readjustment.

j) Pass the water test if:

i) the loss of water does not exceed 1 litre per hour per linear metre per metre internal diameter for vitrified clay and reinforced concrete pipes.
ii) there is no loss of water for pipe other than vitrified clay and reinforced concrete pipe.

iii) these is no visible leakage at the joints for all pipe types.

4.6.3 Handling Water Test Failures

I) Before Backfill

a) Readjust the internal water head to the specified test head if the test section fails the water test. Examine visually for leakage at the external surface of joints.

b) Uncover pipe barrels and inspect for leakage if leakage is not evident at joints. Drain the water and move the downstream plug towards upstream, where necessary, to isolate pipe lengths that fail the water test.

c) Repair or replace pipes before repeating the low pressure water test until the sewer passes the test.

II) After Backfill

a) Isolate pipe lengths that fail the water test by moving the downstream plug towards the upstream end in sections when the test sewer fails the water test. Alternatively, conduct a CCTV inspection, where required, to identify the source of leakage if the source of leakage can not be isolated.

b) Exhume failed pipe lengths and replace.

c) Repeat test until the sewer pipeline passes the test.

4.7 High Pressure Water Test

4.7.1 General

High pressure water test is normally used for testing the pressure sewers and pipeworks within the pump station. The main aims of the test are to ensure the mechanical stability of the pipe and joints can withstand the working pressure. Since the test is conducted under high pressure, the anchorage of the sewer is more critical than the low pressure tests. Preferably, the test should be conducted before backfill. During the test, the test pumps should not be subjected to hydrostatic pressure.

4.7.2 Procedure

a) Seal the sewer pipeline ends using “test-end” units consisting of short lengths of pipe permanently fitted with caps or valves. Connected the
“test-end” units to the test pipe section using a standard coupling, which permits easy removal of “test-end” units after testing.

(The “test-end” units should have a valve with pressure gauge to allow filling of the test length with water or for venting air. The gauge shall be a conventional circular gauge not less than 200 mm diameter and shall be able to read to an accuracy of ± 0.01 Mpa.)

b) For sewer on level grade, fit tees along the test length, where necessary, to ensure all the air can escape. Fit air valves to such tees. Remove air valves and blank off tees after the test is applied.

c) Fit the test pressure gauge at the lowest end of the test length.

(This prevents the test pressure from exceeding the permitted maximum pressure in the test length.)

d) Place pre-constructed temporary thrust blocks behind the test end units to brace against thrust from the test pressures.

(No temporary bracing is permitted along the sewer pipeline. All specified thrust blocks must be constructed and left to cure before testing.)

e) Fill the test length slowly with water through the valve at the lowest test-end unit.

(The water shall be of fair quality and free from sediment. A firm foam swab placed ahead of the water column will improve the expulsion of air.)

f) Set all valves at high spots to vent air.

g) Close the air vents after thorough venting of all air.

h) Fill the test length with water. Leave the filled test length undisturbed for 24 hours prior to testing to allow for absorption of water into the pipes and /or jointing materials.

i) Wipe the exposed fittings and joints clean and dry and check for leakage and other irregularities during this preparatory period. Check also the test pipe for any appreciable movement and disturbance of anchorages. Drain the water and repair any damage found. Repeat the water filling again to start the test.

j) Pump more water into the test length to raise the pressure. Raise the pressure slowly in increments of 1 bars, with pauses of one minute between each increment until achieving the lower of:

i) the maximum rated pressure of the pipes laid, or

ii) 1.5 times the design operating pressure of the pipeline (includes surge allowance)

k) Stop the test immediately should any appreciable drop in pressure be noted during one of these pauses. Determine the cause of the pressure drop. Drain the test length where repairs are required. Start the test again after repairing.
l) Pass the pressure test if there is no reduction from the test pressure in the next 10 minutes after the test pressure is conducted. Do not reduce the pressure as the high pressure leakage test should be conducted immediately after this.

4.8 High Pressure Leakage Test

4.8.1 General

High pressure leakage test normally follows the high pressure water test immediately. This is to avoid any unnecessary pressurising and water filling, which could take time and is costly. The purpose of this test is to ensure the pipe and joint will remain intact under the pressure environment.

4.8.2 Procedure

a) Conduct the test immediately after the high pressure water test. Maintain the following test pressures (whichever is lower) for 24 hours by pumping in make-up water if necessary:
   i) The maximum rated pressure of the pipes laid, or
   ii) 1.5 times the design operating pressure of the pipeline (includes surge allowance).

b) Measure the amount of make-up water pumped into the pipe to maintain the test pressure.

c) Pass the test if the measured amount of make-up water does not exceed 0.1 litre per millimetre of pipe diameter per kilometre of pipe per day for each 3 bars of pressure applied.

d) Reset the test pressure and check all visible joints to locate leakage when the test length fails the test.

4.9 Test for Straightness, Obstruction and Gradient

The sewers shall be check for straightness, obstruction and gradient whenever possible. For gravity sewers and force mains, the gradient and straightness are important to achieve the designed velocity. The following tests are recommended for testing the laid sewer:

I) Test for freedom from obstruction:

a) Visual inspection
b) Insertion of mandrel
c) CCTV inspection
It should be noted that the visual inspection is only for checking a short length. Sufficient lighting shall be provided when carrying out the inspection. For checking a long sewer, insertion of a mandrel should be adopted.

II) Test for grade and straightness

a) Laser beams with sighting targets
b) Sight rails and boning rods
c) CCTV inspection
d) lamp and mirrors
e) Insertion of a smooth balls

The first three methods will provide a more exact assurance for both the gradient and straightness of sewers, which shall be used whenever possible. The latter two methods will provide a rough idea on whether the sewers are laid in certain gradient or straight, which should be used only for a quick check.

4.10 CCTV Inspection

The following subsections outline details on how the CCTV inspection requirements shall be implemented. These guidelines are also aim to enhance professionalism in line with progress in sewerage field, and promote efficiency and cost effectiveness as well as transparency and accountability in sewerage system development.

4.10.1 Objectives of CCTV Inspection

a) Enable detection of sewer defects such as cracks, deformations, collapse, dislocation and etc. which are not detected by normal means.
b) As a quality assurance measure to ensure sewers and sewer appurtenances are constructed in conformability with approved design, specifications, workmanship as well as materials and fixtures used.
c) As a mean to establish record to enhance accountability and professionalism on quality assurance for sewer construction.

4.10.2 Technical Requirements and References

a) Analysis of defects shall be based on WRc Manual for Sewer Condition Classification Latest Edition.
b) Equipment and test devices to be used are as listed in Section 4.10.3.
c) For sewer with diameter larger than 1050 mm, man-entry CCTV survey mode may be adopted unless it can be demonstrated that
the CCTV can be maintained in a stable position on or near the central axis of the sewer and images captured are satisfactory and not distorted.

4.10.3 Equipment Specifications and Test Devices

4.10.3.1 Specifications for CCTV unit’s equipment

a) Solid state colour CCTV camera with pan & rotate features, together with a lighting unit, automatic date/ metre age.

b) A self powered tractor or crawler on which the camera is conveyed along a pipeline under inspection in a stable manner.

c) Calibration chart for various sizes of sewer for the camera used.

d) Test device for the CCTV camera using ‘Marconi Resolution Chart No.1’ or its derivative to demonstrate satisfactory performance of the camera.

e) Test device for the monitor and video recorder to establish the effectiveness and accuracy of the ‘on-site’ monitor and video recorder.

f) The control unit comprises the camera unit, crawler control and screenwriter. This console can be mounted permanently in a vehicle or use as portable system.

g) A video recorder for recording high quality video images.

h) A mean of producing still images from the monitor screen.

i) A PC-based site reporting system capable of producing reports customised to the Contractor’s needs and to include photographs captured directly from video.

4.10.3.2 Software Requirements

Software standardisation using databank software that can produce report based on WRc format.

4.10.3.3 Report Format

Report in VCD or other digital form to be submitted in MPEG format with minimum 352 x 240 pixels. Two copies of digital records and one copy of hardcopy report shall be forwarded to the Commission.

For the diameter pipe greater than 600 mm, it shall have zooming capabilities.

4.10.4 CCTV Inspection Requirements

The following areas are identified as the minimum coverage for CCTV inspection.
4.10.4.1 High Risk Areas

A 100% CCTV inspection shall be conducted for sewers laid in the ground with high risk of failure and having the following characteristics:

a) Average depth of 6 m or more
b) Pipe diameter above 600 mm.
c) Areas that have restricted vehicular access for repair (e.g. central business district).
d) Crossings under buildings, lakes, rivers, roads and railway including their reserve.
e) Ground slopes greater than 30° inclination.
f) All sewers installed using pipe jacking method.
g) All diversion or re-alignment of existing sewer networks.
h) All single private developments (with PE > 30), connecting to existing main sewer.

4.10.4.2 General Inspection Coverage (for Sewer, Manholes and Lateral Connections)

a) Initial CCTV testing & inspection shall be conducted for a minimum 10% random selection of sewers including all manholes and lateral property connections in accordance with standard procedure.
b) If the mandatory requirement of Clause 4.10.4.1 is less than 5% of the entire development area, the minimum CCTV testing & inspection is 10% as in Clause 4.10.4.2a. If the mandatory requirements of Clause 4.10.4.1 is more than 5%, the minimum CCTV testing & inspection shall have an additional of 10%.
c) Prior to taking over existing network that has been approved from any owner or after rehabilitation works have been completed.
d) All new network undergoing intermediate inspection except:
   i) single phase development with total sewer length less than 500 m long with no interval.
   ii) vacuum sewer.

4.10.4.3 Stage of Inspection

a) Stage 1 - All projects are to start with Stage 1 inspection where 10% (by length) of sewer network and property connections involved, shall be randomly selected and CCTV inspected.
b) Stage 2 - Should any Grade 3,4 or 5 conditions as defined in the Manual for Sewer Condition Classification approve by the Commission, found in Stage 1 inspection, the CCTV inspection shall proceed to
Stage 2 inspection. Stage 2 inspections shall include another 40% of the sewer network to be randomly selected for CCTV inspection.

c) Stage 3- Should any Grade 3,4 or 5 conditions as defined in the Manual for Sewer condition classification approved by the Commission found in Stage 2 inspection, the CCTV inspection shall proceed to Stage 3 where by all the remaining network shall under go CCTV inspection.

4.10.5 CCTV Inspection Implementation Procedure for New Sewer Network

4.10.5.1 Activities to be Completed Before Submitting for Final Intermediate Inspection

a) All construction works have been completed and tested by the supervising qualified person.
b) Sewer networks have been cleared of debris and are ready for inspection.
c) A CCTV Inspection Contractor licensed with the Commission has been appointed to carry out the inspection.

4.10.5.2 Random Selection of Sewer to be Inspected

a) The list of sewer segments and house connections selected for CCTV inspection shall be recorded and the parties witnessing the selection process shall duly sign the record.
b) Names and designations of all persons involved in the random selection process as well as the time, date and place where the selection were carried out shall be recorded in the report on the random selection process. Record of the sewer segments randomly selected for CCTV inspection shall be included as appendix in the report.
c) The random selection process shall be completed in a single session.

4.10.5.3 CCTV Inspection on Site

a) The CCTV inspection shall be carried out 7 days after notice issued by the Commission.
b) Inspection shall be carried out within 24 hours after random selection has been completed.
c) Once started, CCTV inspection for a project shall be carried out without any break. Should for any reason a break/delay of more than 24 hours become necessary, the random selection process shall be repeated to select the remaining sewer segments for the inspection. Reasons for the break/delay shall be recorded.
d) Representative from the Commission or authorized person, consultant representative and contractor responsible for the construction of the sewer shall be present at the onset of CCTV inspection at each project site.

4.10.5.4 Documentation on CCTV Recording

a) At the start of the CCTV recording, the following details must be recorded:
   i) Date and starting time of inspection.
   ii) Project name and location.
   iii) Names and designation of persons involved (i.e. representative of the Commission or authorized person, consultant & contractor and CCTV contractor).

b) At the beginning of each CCTV recording, every segment of sewer shall be marked with their respective code number with chainage together with the date, start and end times of the recording.

c) After the CCTV inspection and recording have been completed for a project, a copy of recorded CCTV shall be handed over to the Commission or authorized person immediately. Report on the CCTV inspection together with the recording and recommendations shall be prepared by the CCTV contractor and submitted to the relevant Commission regional office or the appointed agency not more than 7 days after the date of inspection. The format of reporting shall follow the standard that had been given (Appendix C). The copy of the tape (or other recording media used to store the record) containing the CCTV inspection records shall be submitted to the Commission regional office or the appointed agency together with a certificate duly signed by the qualified person responsible for the CCTV inspection declaring the authenticity of the recording submitted and that the CCTV inspection has been done in accordance with the procedure stated in this guideline.

4.10.6 Interpretation of Results from CCTV Inspection

a) Classification: Grade 1 to Grade 5 as per the Commission approved Sewer Assessment Classification. The defect grade description shall follow the following colour code:
   i) Grade 1: Green
   ii) Grade 2: Blue
   iii) Grade 3: Orange
   iv) Grade 4: Brown
   v) Grade 5: Red
b) Grade 1 and 2 is acceptable constructional defects but may have other minor defects. It can be accepted provided a performance bond has been submitted and the contractor undertake to rectify the defect within 30 days.

c) Sewer with Grade 3, 4 or 5 conditions has major structural defects and shall not be accepted. Relaid of the affected sewer segments is necessary.

4.10.7 Follow Up Action to Be Taken

a) For Grade 1 and Grade 2, the developer shall rectify and make good to all the defects in 30 days. These rectification works shall be witnessed by the parties concerned and agreed together that the works had been completed. The Commission or the authorised person may instruct CCTV inspection to be carried out again. Under these grade classifications, the letter of recommendation for CFO will be released by the Commission or the authorised agency.

b) For Grade 3, 4 or 5 classifications, the developer shall change, replace, relay or reconstruct the rejected works. Further CCTV inspection shall be carried out before acceptance. The letter of support for CFO will be released upon acceptance.

c) In the events of any blockages, damages, seepages and etc to the sewer networks during the defects liability period, the Commission may require the developer to carry out further CCTV inspection to determine the cause and extent of the problems that arises. CCTV inspection shall be carried out immediately within 24 hours.

Table 4.2 provides the description of various defect grades
Table 4.2 Defect Grades Descriptions

<table>
<thead>
<tr>
<th>Grade 1</th>
<th>Occurrences without damage and no cracks of pipe but only acceptable displacement on joint where no visual infiltration can be observe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 2</td>
<td>Constructional and sewer product deficiencies or occurrences with insignificant influence to tightness, hydraulic or static pressure of pipe, etc.</td>
</tr>
<tr>
<td></td>
<td>Examples: Joint displaced large; badly torched intakes; minor deformation of plastic pipes (&lt;5%); minor erosions; infiltration seeping; Cracks – joint, circumference, longitudinal; Debris, silt – 15%; Encrustation light.</td>
</tr>
<tr>
<td>Grade 3</td>
<td>Constructional, operational and maintenance deficiencies diminishing static, hydraulic, safety and tightness.</td>
</tr>
<tr>
<td></td>
<td>Examples: Infiltration dripping. (OMD); Open joint; untorched intakes; cracks; minor drainage obstructions such as calcide build ups; protruding laterals; minor damages to pipe wall; individual root penetrations; corroded pipe wall; flexible pipe deformation (&gt;5%); Lining defect.</td>
</tr>
<tr>
<td>Grade 4</td>
<td>Constructional and structural damages with no sufficient static safety, hydraulic or tightness.</td>
</tr>
<tr>
<td></td>
<td>Examples: axial/radial pipebursts; visually noticeable infiltration/exfiltration; cavities in pipe-wall; severe protruding; laterals severe root penetrations; severe corrosion of pipe wall; Infiltration running; encrustation medium; minor deformation; flexible pipe deformation &gt;15%.</td>
</tr>
<tr>
<td>Grade 5</td>
<td>Major structural damaged where pipe is already or will shortly be impermeable.</td>
</tr>
<tr>
<td></td>
<td>Examples: collapsed or collapsed eminent; major deformation; deeply rooted pipe; any drainage obstructions; pipe loses water or danger of backwater in basements etc.</td>
</tr>
</tbody>
</table>
4.11 Infiltration Test

4.11.1 General

Infiltration is an extraneous flow not contributed from households. Although design has allowed for certain amount of infiltration, a significant amount of unexpected infiltration will overload both the collection sewers and the sewage treatment plant. To avoid any extra infiltration, a test maybe conducted on the gravity sewer laid. If the force main is significantly below the groundwater table, an infiltration test is also highly recommended. When severe infiltration is found during sewer laying, the source shall be investigated immediately.

Infiltration test is normally conducted after backfill and after the groundwater level has stabilised. The procedures are as follows:

4.11.2 Procedure

a) Plug the inlets at all upstream open ends, after the groundwater level has stabilised following backfilling.
b) Measure any infiltration from the sewer to the manhole or within manhole itself.
c) Conduct the measurement of infiltration for at least 24 hours.
d) Pass the infiltration test if the infiltration does not exceed 1 litre per hour per metre diameter per meter of pipe run.

4.11.3 Handling Test Failures

a) Conduct a light and mirror test to identify the location of the infiltration if the pipe is small and short.
b) Move an inflated rubber plug toward downstream end to isolate lengths of leakage. Repeat the test procedure after each plug relocation.
c) Conduct a CCTV inspection if the location of the infiltration can not be identified by the light and mirror test or by the movement of the inflated rubber plug.
d) Exhume and repair the fail section of the pipe.

4.12 Watertightness Test

4.12.1 General

Visual inspection is usually sufficient to ensure the watertightness of manhole and other ancillary structures. However, watertightness test may be required if:
a) Instruction from the authorised inspection person.
b) Unsatisfactory features identified from the visual inspection.
c) Suspicion of poor workmanship or poor materials.
d) Leakages revealed from other tests.
e) Frequent surcharging of the structure is possible.

The test should be carried out only after the structures have achieved sufficient strength to withstand the test pressure. Where possible, the test shall be carried out before backfilled or concrete surrounded.

For manhole less than 1.5 m in depth, the manhole shall be filled with clean water to the bottom of cover. For manhole more than 1.5 m in depth, the water head for the test shall not be less than 1.5 m or the mean groundwater level, whichever is larger. For any other ancillary structure, the water shall be filled to the top of the structure unless otherwise specified by the authorised inspection person.

The procedures for testing the manhole are listed below. For other ancillary structures, the procedures can still be adopted. However, the height which the water level should be tested shall follow the instruction from the authorised inspection person.

4.12.2 Procedures

a) Fit a plug or stopper in all the openings.
b) Secure the plug/stopper to resist the full test pressure.
c) Provide a mean to remove the plug/stopper from the ground level safely if test water is allowed to be discharged to the downstream.
   (The plug/stopper may need to be remove while the structure is still full of water. Alternatively, a potable submersible pump might be sunk into the test structure to remove the water.)
d) Fill the structure with clean water. Fill slowly to avoid any intense pressure impact from the water.
e) Observe visually to identify any water leakage to the outside of the structure. Drain the water to repair the leakage if necessary.
f) Otherwise, allow the water to stay in the test structure for 8 hours. Investigate any appreciable water loss.
g) Drain and dispose of the test water from the test structure in an appropriate manner and to a suitable location.