



Engineering Standard

SAES-L-650

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Construction of Nonmetallic Piping in Hydrocarbon and Water Injection Systems

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Saudi Aramco DeskTop Standards

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1 Scope

1.1 This Installation, Inspection, and Testing Standard provides the requirements for field installation of Reinforced Thermosetting Resins (RTR) pipe and pipeline for use in the following applications:

- Flowlines and testlines
- Water injection systems

1.2 This Construction Standard applies to:

- Buried piping systems.
- Above ground piping systems with prior approval from the Manager, Consulting Services Department and the Manager, Loss Prevention Department.
- High pressure piping systems (MAOP \geq 500 psi) and low pressure piping systems (MAOP $<$ 500 psi).

1.3 The following services are excluded from the scope of this standard:

- In-plant piping systems
- Flowlines, testlines and water injection systems located in other than class 1 location.
- Potable water systems, fire and raw combined water systems, irrigation water systems, well water systems, and gravity draining systems in Saudi Aramco facilities, shall be designed in accordance with Saudi Aramco Plumbing and Utilities Standards.
- Oily water systems shall be designed in accordance with SAES-L-610.

2 Conflicts and Deviations

2.1 Any conflicts between this standard and other applicable Saudi Aramco Engineering Standards (SAESs), Materials System Specifications (SAMSSs), Standard Drawings (SASDs), or industry standards, codes, and forms shall be resolved in writing by the Company or Buyer Representative through the Manager, Consulting Services Department of Saudi Aramco, Dhahran.

2.2 Direct all requests to deviate from this standard in writing to the Company or Buyer Representative, who shall follow internal company procedure SAEP-302 and forward such requests to the Manager, Consulting Services Department of Saudi Aramco, Dhahran.

3 References

The selection of material and equipment, and the design, construction, maintenance, and repair of equipment and facilities covered by this standard shall comply with the latest edition (at the project cut-off date) of the references listed below, unless otherwise noted.

3.1 Saudi Aramco References

Saudi Aramco Engineering Procedures

<i>SAEP-13</i>	<i>Environmental Assessment</i>
<i>SAEP-14</i>	<i>Project Proposal</i>
<i>SAEP-122</i>	<i>Project Records</i>
<i>SAEP-302</i>	<i>Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement</i>
<i>SAEP-334</i>	<i>Retrieval, Certification and Submittal of Saudi Aramco Engineering & Vendor Drawings</i>
<i>SAEP-363</i>	<i>Pipelines Simulation Model Development and Support</i>

Saudi Aramco Engineering Standards

<i>SAES-A-004</i>	<i>General Requirements for Pressure Testing</i>
<i>SAES-A-007</i>	<i>Hydrostatic Testing Fluids and Lay-Up Procedures</i>
<i>SAES-A-114</i>	<i>Excavation and Backfill</i>
<i>SAES-B-064</i>	<i>Onshore and Nearshore Pipeline Safety</i>
<i>SAES-H-001</i>	<i>Selection Requirements for Industrial Coatings</i>
<i>SAES-H-200</i>	<i>Storage, Handling, and Installation of Externally Coated Pipe</i>
<i>SAES-L-100</i>	<i>Applicable Codes & Standards for Pressure Piping Systems</i>
<i>SAES-L-105</i>	<i>Material Specifications for Piping Systems</i>
<i>SAES-L-108</i>	<i>Selection of Valves</i>
<i>SAES-L-109</i>	<i>Selection of Flanges, Bolts and Gaskets</i>
<i>SAES-L-110</i>	<i>Limitation on Piping Joints and Components</i>
<i>SAES-L-120</i>	<i>Piping Flexibility</i>

<i>SAES-L-125</i>	<i>Safety Instruction Sheet for Piping and Pipelines</i>
<i>SAES-L-132</i>	<i>Material Selection of Piping Systems</i>
<i>SAES-L-143</i>	<i>Thermal Expansion Relief in Piping</i>
<i>SAES-L-150</i>	<i>Pressure Testing of Plant Piping and Pipelines</i>
<i>SAES-L-460</i>	<i>Pipeline Crossings under Roads and Railroads</i>
<i>SAES-L-620</i>	<i>Design of Reinforced Thermosetting Resins (RTR) Piping in Hydrocarbon and Water Injection Systems</i>
<i>SAES-Q-001</i>	<i>Criteria for Design and Construction of Concrete Structures</i>
<i>SAES-Q-005</i>	<i>Concrete Foundations</i>

Saudi Aramco Materials System Specification

<i>01-SAMSS-042</i>	<i>Reinforced Thermoset Resin (RTR) Pipe and Fittings in Water and Hydrocarbon Services</i>
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Saudi Aramco Standard Drawing

<i>AD-036973</i>	<i>Marker Plates for Pipeline Kilometer Marker</i>
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3.2 Industry Codes and Standards

American Petroleum Institute

<i>API 15 L4</i>	<i>Recommended Practice for care and Use of Reinforced Thermosetting Resin Line Pipe</i>
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International Organization for Standardization

<i>ISO 14692</i>	<i>Petroleum and Natural Gas Industries – Glass- Reinforced Plastics (GRP) Piping</i>
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American Water Works Association

<i>AWWA M45</i>	<i>Fiberglass Pipe Design</i>
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3.3 Saudi Government

<i>SSD-29</i>	<i>Saudi Security and Safety Directives</i>
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4 Design Package and Project Records

- 4.1 The construction of the pipeline shall follow the approved design package as required per SAES-L-620.

- 4.2 The Construction Contractor may issue detailed design drawings, sketches and procedures as needed during the course of construction or as specified in the Project Scope of Work. These shall be approved by Saudi Aramco PMT and the Proponent Representative prior to implementation.
- 4.3 Saudi Aramco PMT is responsible for updating the as built drawings. They shall ensure that Construction Contractor is recording the as built information.
- 4.4 The Saudi Aramco PMT shall approve the Construction Contractor's final profile.

5 General Construction Requirements

- 5.1 Field installation, inspection, and pressure testing shall be conducted by qualified personnel.
- 5.2 The pipe shall be laid-out and supported in accordance with the Engineering Design (engineering and construction drawings supported by design calculations).
- 5.3 Fiberglass pipe shall not be field routed without approval by the Design Engineer.
- 5.4 Elastic bending of the pipe to follow contour shall be controlled to be within the pipe manufacturer curvature limit.
- 5.5 All deviations from the design shall be requalified.

6 Receipt Inspection and Storage

- 6.1 Receipt Handling
 - a) Receipt handling, lifting, unloading and transport shall be performed in accordance with manufacturer procedures.
 - b) Do not allow pipe to roll off to ground or racks.
 - c) Pipe may be lifted with a sling provided the sling is a canvas or compatible plastic, at least 4 in wide.
 - d) Pipe shall be transported in a container or pallet that does not permit contact pipe-to-pipe nor relative movement of the pipe during transport.
 - e) Fittings shall be loaded onto pallets with packing to prevent contact fitting-to-fitting or relative movement of the fitting during transport.
 - f) Pipe spools shall be lifted by at least two slings to evenly support the weight and prevent overturning or fall.
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- g) Additional handling requirement shall comply with 01-SAMSS-024.

6.2 Receipt Inspection

- a) The trailer load or container load shall be checked for load shifting which may have occurred during transportation.
- b) The ends shall be checked for missing or broken end protectors.
- c) The quantities of pipes and fittings shall be checked.
- d) All pipe and fittings shall be inspected for conformance to the Purchase Order specification requirements.
- e) Joining kits (adhesive bonds, lubricants, etc.) shall be inspected for conformance to the manufacturer installation manual and the Engineering Design, and for evidence of damage or tempering.
- f) The pipe label shall be inspected to verify conformance to the required specifications. As a minimum the label shall confirm the pipe manufacturer, size, material, and pressure rating.
- h) The product code for each pipe and fitting shall be verified to be traceable to the material certificate prior to installation.
- i) Pipes and fittings shall be inspected to assure that each end is properly sealed with a cap.
- j) Pipes and fittings shall be inspected for evidence of damage or distortion, applying the Inspection criteria in Appendix A.
- k) Mark and quarantine pipes or fittings which do not pass the receipt inspection, pending disposal or repair.
- l) Vendor inspection release note shall be completed prior to shipment.

6.3 Storage

- a) Yard storage shall be in accordance with the manufacturer requirements.
 - b) The pipes shall be set on a flat surface, free of sharp edges.
 - c) Pipes shall be adequately supported in accordance to manufacturer requirements.
 - d) Maintain end protectors throughout storage.
 - e) If they are to be bundled, pipes and fittings shall be secured by straps; chains are not permitted.
 - f) Precautions shall be in place to tie-down pipes and fittings to prevent overturning or fall.
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- g) Gaskets and adhesive systems and lubricants shall be stored in their original packing in accordance with the manufacturer recommendations.
- h) The stored adhesive systems or lubricants shall be discarded if they have an obsolete shelf life.

7 Installation of Buried Pipe

7.1 Soil Characteristics

- a) The various parts of a soil trench are illustrated in Appendix A, Figure A-1.
- b) The soil trench, width, depth, shall be in accordance with the design drawing.

7.2 Trenching

- a) Trench safety shall be in accordance with SAES-A-114.
 - b) The pipe depth shall be determined by engineering design and documented in construction drawings.
 - c) Surveys shall be conducted prior to excavation to confirm that there are no other buried commodities which could interfere or be damaged by excavation.
 - d) If the trench is excavated on the slides of a slope, the slope shall be less than 15 degrees. For steeper slopes and for excavation in an area of unstable soil a geotechnical feasibility investigation is required prior to trenching, to verify short term and long term stability.
 - e) Excavate trench and provide trench walls as necessary to ensure that sides are stable under working conditions.
 - f) Dewater the trench if necessary prior to installation of bedding, pipe and backfill.
 - g) The trench shall be clean, free of organic materials, tree roots, and other extraneous materials.
 - h) Shoring sheeting may be placed between the native soil along the side of the trench and the trench fill if the sides of the trench are unstable.
 - i) The trench shall be sufficiently wide to accommodate the installation.
 - j) For multiple pipes in the same trench, the space between pipes should be at least 1 m.
 - k) The slope of the pipe trench shall be verified not to exceed the permitted curvature of the pipe.
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7.3 Foundation and Bedding

- a) Prefabricated pipe spools shall contain piping isometric drawings.
- b) If necessary to achieve the required pipe depth and pipe slope, a foundation may be installed at the bottom of the trench.
- c) Bedding shall be installed in all cases below the pipe, and shall be a minimum of 6 in. (150 mm) deep.
- d) The bedding shall be clean (rock-free and fines-free) sand, or granular, with 100% passing 19 mm (3/4 in) sieve, 90 to 100% passing a 9.5 mm (3/8 in) sieve and not more than 4% passing 75 mm (No. 200 sieve).
- e) The bedding shall be shaped to provide uniform support in the haunch (saddle) zone along the full length of the pipe, without voids between the bedding and the pipe (Figure B-1).
- f) If the pipe joints are larger than the pipe, the bedding profile shall be shaped to accommodate the joint.
- g) The haunch (saddle) zone under the pipe shall be backfilled first.

7.4 Placement of Pipe in the Ditch

- a) Pipe 4 in. and smaller may be double joined outside the ditch then lifted and placed into the ditch. Lift using wide straps not chains.
- b) When lifting the pipe, do not exceed the curvature limit specified by the pipe and fitting manufacturer.
- c) Larger pipes (> 4 in.) or heavy wall pipe shall be joined in the ditch.
- d) Environmental conditions (sand, wind, water) should be such as not to have water or foreign material penetrates or contaminates the interior of the pipe and the surface of the joints.

8 Joining

8.1 High Pressure Piping System

- a) Only make-up tools and wrenches supplied by the pipe and fitting manufacturer (and appropriate for the pipe size and joint type) shall be used in handling pipes and fittings, and making joints.
 - b) If pipe segments must be pulled, the pull force shall not exceed the manufacturer specified tensile load limit.
 - c) Joining shall be in accordance with the pipe and fitting manufacturer joining manual.
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- d) Each threaded joint shall be inspected for evidence of proper penetration of male-female threads, within the limits specified by the manufacturer.
- e) Pipes and fittings from different manufacturers shall not be inter-mixed.
- f) Joining shall be performed by personnel trained and certified by manufacturer in accordance with construction manual.
- g) Thread protectors shall be left in place until ready for joining.
- h) Threads shall be cleaned and carefully inspected before joining and shall be free from any visible damage. Thread damage evaluation shall be in accordance with the manufacturer construction manual. Where criteria are not established, any thread damage shall be cause for rejection until resolved in writing by the manufacturer.
- i) Threaded fittings shall be assembled with lubricants and sealants specified by the pipe manufacturer for the fluid and pressure. Do not inter-mix lubricants or sealants from different manufacturers.
- j) Lubricant applications, including application technique, specific handling, exposure and storage requirements shall be in accordance with the manufacturer requirements.
- k) Pipes shall be aligned prior to joining, in accordance with manufacture installation procedure.
- l) Thread joining shall be in accordance with manufacturer installation procedure.
- m) Once jointed, threaded joints shall be inspected in accordance with the manufacturer recommendations. In particular, thread engagement shall be within the limits specified by the manufacturer.

8.2 Low Pressure Piping System

- a) Only make-up tools and wrenches supplied by the pipe and fitting manufacturer (and appropriate for the pipe size and joint type) shall be used in handling pipes and fittings, and making joints.
 - b) If pipe segments must be pulled, the pull force shall not exceed the manufacturer specified tensile load limit.
 - c) Joining of low pressure piping system shall be in accordance with the pipe and fitting manufacturer recommendations.
 - d) Joining shall be in accordance with the pipe and fitting manufacturer joining manual.
 - e) Joining shall be performed by personnel trained and certified by the manufacturer in accordance with construction manual.
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9 Inspection of Pipe and Joints

9.1 Inspection

- a) When the pipe has been placed in the ditch, and prior to hydrotest, it shall be visually inspected.
- b) The Inspection shall cover the full outer surface and accessible portions of the inner surface.
- c) The Inspection shall identify signs of damage or poor workmanship.
- d) For high pressure pipe, both thread condition and thread engagement shall be verified against manufacturer requirements.
- e) Visual inspection results (thread condition, joint ends, joint preparation, fit-up and engagement) of each connecting joint shall be documented in a logbook and marked on the joint with a permanent marker by the inspector. This shall also include the installer's initial and date of installation/inspection to track the installer's job performance.
- f) Where damages or poor workmanship are identified, they shall be reported in inspection logbook for corrective action. A connecting joint identification system shall be developed.
- g) Manufacturer-certified installers shall be identified by full name and badge numbers on a work roster, to be available and approved by Saudi Aramco before work begins. Inspection of the initial 25 joints production (or 500 meters) for each installer shall be an inspection hold point. Poor workmanship or failure to follow manufacturer specific instructions for assembly shall be cause to remove the installer from the work roster and assembly duties.

9.2 Acceptance Criteria

- a) The visual acceptance or rejection of pipe and fittings shall be in accordance with Appendix A.
 - b) Pipe and fittings shall be examined for evidence of impact damage, against visual standards obtained by hammer-impact of a sample pipe.
 - c) Pipe and fittings shall be examined for evidence of blisters.
 - d) Pipe and fittings shall be examined for evidence of burn.
 - e) Pipe and fittings shall be examined for evidence of loose fibers or excessive UV-induced fiber blooming.
 - f) Pipe and fittings shall be examined for evidence of chemical attack and loss of surface resin.
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- g) Pipe and fittings shall be examined for evidence of cracks.

10 Backfill of Trench

10.1 Backfill for Initial Hydrotest

- a) When the first 500 m of pipe is installed, it shall be hydrotested prior to continuing installation of the system.
- b) Each connecting joint, and approximately 0.6 m (2 ft) on each side of the connecting joint shall be left uncovered for hydrotest. If this is not feasible, contact the Design Engineer.
- c) The hydrotest shall be conducted in accordance with Section 7.

10.2 Final Backfill

- a) Construction of the rest of the line may proceed following the successful initial hydrotest on the first installed 1.5 km.
- b) When the complete line has been installed in the ditch, it shall be prepared for full system hydrotest.
- c) A minimum of one bucket of fill shall be placed in the middle of each pipe run.
- d) Each connecting joint, and approximately 0.6 m (2 ft) on each side of the connecting joint shall be left uncovered for hydrotest. If this is not feasible, contact the Design Engineer.
- e) The hydrotest shall be conducted in accordance with Section 7.
- f) Following successful completion of the hydrotest, the line shall be covered and the trench filled.
- g) Backfill should be placed and compacted in lifts not exceeding 6 in. (150 mm), and compacted in accordance with the Engineering Design.
- h) The compacting equipment shall not contact the pipe. If contact does occur, the Construction Engineer shall be notified for inspection and repair or disposal.
- i) Native soil may be used for lifts passed 6 in. (150 mm) above the top of the pipe, provided the soil does not contain organic materials and is not unstable SC5.
- i) Minimum cover shall be in accordance with the Engineering Design.

11 Hydrotest

11.1 Requirement

Newly constructed piping and pipeline shall be hydrostatic testing at completion of construction, following Inspection.

11.2 Test Preparation

- a) Company procedures for the planning and conduct of a safe and reliable hydrotest, its documentation, and post-test disposition of hydrotest water, shall apply in accordance with GI-0002.102.
- b) A pressure relief device shall be provided near the hydrotest pump to prevent exceeding the hydrostatic test pressure.
- c) Cleanliness prior to testing shall be verified by runs of soft pigs propelled by water in accordance with SAES-A-007.
- d) The test water shall be clean. Its quality and source should be determined. Water that contains any percentage of sediment and acid may injure the pipe, valves, and equipment, and should not be used unless it is filtered and inhibited. The possible deleterious effect of additives or inhibitors in the hydrotest water on the processing of liquid petroleum to be transported should be addressed with the pipe supplier prior to testing.
- e) The line shall be filled with hydrotest water, vented, and be free of air or gas.
- f) The test shall not be conducted below freezing temperature.

11.3 Conduct of Test

- a) Once the line is full of water, the pressure shall be raised in increments: Increment of 150 psi (10 bar) for test pressure below 1000 psi. Increment of 250 psi (17 bar) for test pressure above 1000 psi.
- b) Hold the pressure for 5 minutes at each increment.
- c) The pipeline shall be tested at the pressure and duration defined in the following Section.

11.4 Test Pressure

- a) Liquid piping systems shall be subjected to a hydrostatic test at $1.5 \times$ MAOP (maximum allowable operating pressure), but not to exceed 1.5 times the rated pressure of the lowest rated component.
 - b) The duration of the hydrotest shall be not less than 4 hr, and shall be sufficient for a thorough visual investigation of each joint.
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- c) The hydrotest pressure must be achieved at the highest elevation (lowest hydrostatic head) point in the line.
- d) The test pressure shall not exceed the manufacturer rated pressure of the pipe, components and fittings at any point in the pipeline.

11.5 Pressure Change

- a) The pressure in the line should remain constant during the duration of the test, except for documented corrections due to changes in ambient temperature.
- b) Minor or gradual pressure changes during the test can be a result of residual air in the segment or temperature effects.
- c) Extending the test duration can demonstrate that air and temperature effects have been accounted for.
- d) If ambient temperature correction of the test pressure is required, a continuous-recording temperature measurement device should be provided to register a permanent record of pipeline temperature versus time.
- e) Pressurization of the section should occur at a controlled rate to avoid surging the line.
- f) Pipe joints should be periodically checked for leaks during pressurization.
- g) The flow rate should be monitored and logged for preparation of a pressure-volume P-V plot, if applicable.
- h) Calculations indicating the amount of squeeze fluid required to go from the fill pressure to the test pressure should be made prior to the test and given to test personnel. This information aids in determining the tightness of the segment and assists in determining, along with the P-V plot, if leaks have occurred or if the pipe has yielded.
- i) The results of the pressure checks and temperature readings should be recorded on the pressure and temperature test log within at least 30-minute intervals.
- j) Ambient temperature changes that could affect the pressure and temperature recording charts should be documented on the test log.
- k) The volume or pressure of any added or subtracted test medium should be documented on the test log, as well as the temperature and pressure at that time and be accounted for in the assessment of the results of the pressure test.

11.6 Leak Detection

If during hydrotest there is evidence of leakage, the leak source shall be

identified and repaired, and the hydrotest repeated.

12 Special Considerations

12.1 Roadway Crossing

If required by the Engineering Design, the pipe shall be placed in a steel or concrete conduit (sleeve) at roadway crossings in accordance with SAES-L-460.

12.2 Pipe below Water Table

- a) If the pipe may be below the water tables, or if the area is prone to flooding, the pipe shall be anchored if required by the Engineering Design.
- b) It may be necessary to use crushed rock or pea gravel as bedding and backfill material. The Geotechnical Engineer should be consulted.

13 Above-Ground Installation

13.1 As-Built Verification

As-built drawings shall be developed after installation of the piping system, and verified to be in accordance with the Engineering Design.

13.2 Hydrotest

- a) The same standard procedures and precautions as hydrotest of steel pipe shall apply.
- b) The test pressure shall be the same as for buried pipe.

Appendix A – Visual Inspection Acceptance Criteria

Defect	Description	Criterion	Disposition
Note: The following acceptance criteria apply to the pipe body and fitting body, away from threads or sealing surfaces. No defects are permitted on threads or sealing surfaces.			
Burn	Distortion or discoloration of the FRP product surface.	None permitted.	Reject
Chip	Small piece broken from edge or surface. If reinforcement fibers are broken, the damage is considered a crack.	If there are undamaged, fibers exposed over any area; or no fibers are exposed but an area greater than 10 mm x 10 mm lacks resin.	Minor repair
		If there are no fibers exposed, and the area lacking resin is less than 10 mm x 10 mm	Accept
		If more severe than the above	Reject
Crack	Sharp cut that reaches the reinforcing fibers.	None permitted.	Reject
Crazing	Fine hairline cracks at or under the surface of the component.	Crack lengths greater than 25.0 mm.	Minor repair
		Crack lengths less than 25.0 mm.	Accept
Dry spot	Area of incomplete surface film where the reinforcement has not been wetted by resin.	None permitted.	Reject
Inclusion	Foreign matter molded into the component.	None permitted.	Reject
Pin hole	Small round pit or porosity	Superficial, does not penetrate the reinforcement, less than 1 mm depth, and less than 1 per m ² .	Accept
Fracture	Rupture of the component with complete penetration of the laminate. Majority of fibers broken. Visible as lighter colored area of inter-laminar separation.	None permitted.	Reject
Impact mark	Discoloration and possible bubble reaching the reinforcement. Impact a spare sample with a hammer for reference.	None permitted	Reject
UV induced fiber blooming	Discoloration and increased roughness of the pipe surface	None permitted on UV-protected pipe.	Reject
Void	Air bubble	Superficial and less than 2 mm diameter and 0.5 mm deep, and less than 4 voids per m ²	Accept
		If more severe than the above.	Reject
Wear scratch	Shallow mark caused by improper handling, storage and/or transportation. If reinforcement fibers are broken, the damage is considered a crack.	If there are undamaged, fibers exposed over any area; or no fibers are exposed but an area greater than 10 mm x 10 mm lacks resin.	Minor repair
		If there are no fibers exposed, and the area lacking resin is less than 10 mm x 10 mm	Accept
		If more severe than the above.	Reject

Appendix B – General Description of Trench

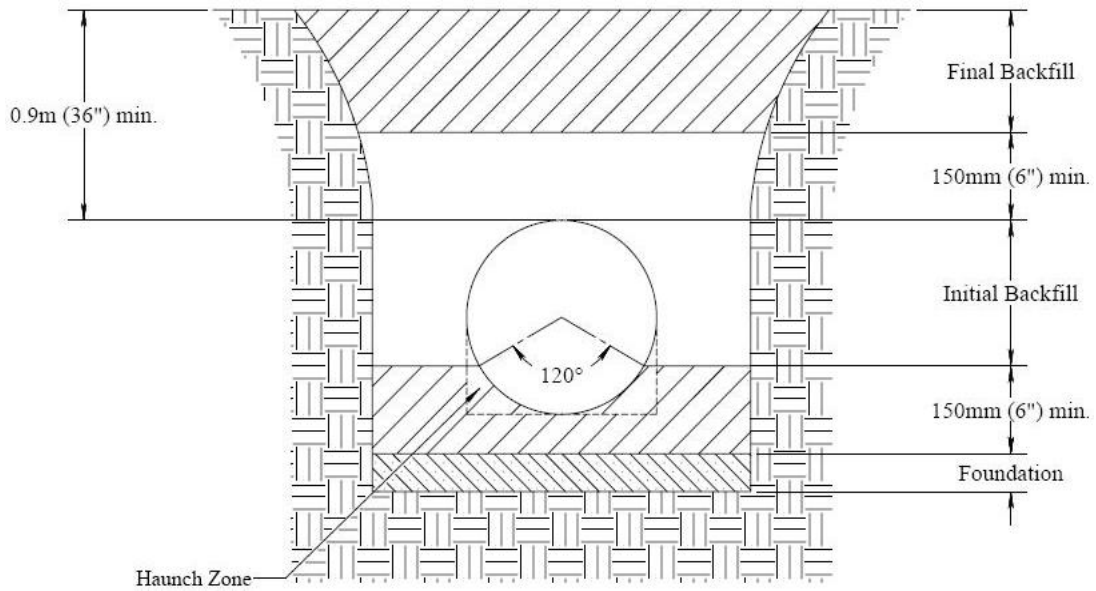


Figure B-1 – General Trench Description