Engineering Standard

SAES-S-030 31 August 2005

Storm Water Drainage Systems

Saudi Aramco DeskTop Standards

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1 Scope

1.1 This Saudi Aramco Engineering Standard sets forth the minimum requirements for storm water drainage systems under the operation and maintenance of Saudi Aramco.

1.2 This Standard does not include building roof drainage systems, which shall be designed in accordance with the Saudi Aramco Building Code SAES-M-100 and Appendix D of the Saudi Aramco Plumbing Code SAES-S-060.

1.3 This Standard does not include industrial drainage and sewer systems, and oily water sewer systems. Such systems are covered in SAES-S-020. Storm water drainage systems that are part of an oily water sewer system shall be designed, installed and tested in accordance with SAES-S-020.

Where an oily water sewer system is neither justified nor desirable, a storm surface drainage system shall be provided. Approval to use a storm surface drainage system shall be obtained from the Chief Fire Prevention Engineer, Loss Prevention Department, Dhahran with the concurrence of the Proponent Department Manager.

1.4 This Standard does not include drainage along the pipeline route in rural, wadi or mountainous areas.

Commentary Note:

For pipeline washout protection, site specific drainage studies should be performed.

2 Conflicts and Deviations

2.1 Any conflicts between this Standard and other applicable Saudi Aramco Engineering Standards (SAESs), Materials Systems Specifications (SAMSSs), Standard Drawings (SASDs), or industry standards, codes, and forms shall be resolved in writing by 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

All referenced specifications, standards, codes, forms, drawings and similar material shall be of the latest issue (including all revisions, addenda and supplements) unless otherwise stated.

3.1 Saudi Aramco References

Saudi Aramco Engineering Procedure

SAEP-302	*Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirements*

Saudi Aramco Engineering Standards

SAES-A-100	*Survey Coordinate Datums*
SAES-A-112	*Meteorological and Seismic Design Data*
SAES-M-100	*Saudi Aramco Building Code*
SAES-Q-001	*Criteria for Design and Construction of Concrete Structures*
SAES-Q-010	*Cement Based, Non-Shrink Grout for Structural and Equipment Grouting*
SAES-S-010	*Sanitary Sewers*
SAES-S-020	*Industrial Drainage and Sewers*
SAES-S-060	*Saudi Aramco Plumbing Code*
SAES-S-070	*Installation of Utility Piping Systems*

3.2 Industry Codes and Standards

AASHTO

HDG-3 VOL IV	*Guidelines for Hydraulic Design of Culverts*

American Society for Testing & Materials

ASTM C76M	*Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Metric)*
ASTM C443	*Joints for Circular Sewer and Culvert Pipe, Using Rubber Gaskets*
ASTM C14	*Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe*

Federal Aviation Administration (FAA)

The Asphalt Institute

MS-15 *Drainage of Asphalt Pavement Structures*

4 Design

4.1 General

4.1.1 Storm water drainage shall be designed to protect all buildings, roads, equipment, structures, and pipeways and to minimize erosion of soils.

4.1.2 Surface drainage from unpaved areas shall not drain over paved areas.

4.2 Time of Concentration

4.2.1 The initial time of concentration (Tc) for drainage area shall be determined from FAA (Federal Aviation Administration) formula:

$$Tc = \frac{3.26\,(1.1 - C)\,(D)^{1/2}}{(S)^{1/3}} \qquad (1)$$

Where:

Tc = Time of concentration (surface flow time) in minutes.

C = The runoff coefficient Table 1

D = Distance to the most remote point (m).

S = Slope (%).

4.2.2 The Tc(i) of different ground character or land use within a drainage subarea shall be calculated separately and adjusted to arrive at the initial Tc for the entire sub-area.

4.2.3 The Tc from drainage junction to junction shall be cumulative as:

Tc(2) = (1) + travel time in a storm drain pipe or open channel from junction to junction.

4.2.4 The Tc used for the calculation of the quantity of runoff shall be not less than 10 minutes. In the event that the actual initial Tc is less than 10 minutes, then a 10 minute Tc shall be used until the Tc as calculated per Section 4.1.3, exceeds 10 minutes.

4.3 Storm Return Frequency

The storm return frequencies for Saudi Aramco facilities and types of drainage systems shall be 5 years.

4.4 Rainfall Intensity

The rainfall intensity (I) in millimeters per hour, for the determined time of Tc and the specified return frequency shall be calculated in accordance with SAES-A-112 Note 3.

4.5 Runoff Quantity

4.5.1 The runoff coefficient shall be adjusted for each drainage area according to the character of the land use or ground.

4.5.2 The runoff quantity for each drainage area shall be determined by the use of the Rational formulae:

Drainage area is less than or equal to 404.85 hectares (1000 acres), (4.048 km^2)

$$Q = 0.002755 * C * I * A \quad (2)$$

Drainage area is more than 404.85 hectares (1000 acres), (4.048 km^2)

$$Q = 0.003 * C * I * A\ (S/A)0.25 \quad (3)$$

Commentary Note:

This formula was taken from the Asphalt Institute MS 15.

Where:

Q = Runoff quantity in cubic meters per second.

C = Runoff coefficient from Table 1 of this Standard.

I = Rainfall intensity in millimeters per hour in accordance with SAES-A-112 for duration equal to time of concentration.

A = Drainage area in hectares.

S = Average slope of ground in the drainage area, in meter per 305 meters.

Table 1 – Runoff Coefficient

Character of Drainage Area	C
Pavement, roads and parking lots	0.9
Compacted marl or open rocky areas	0.8
Commercial or Community Services areas	0.7
Residential areas	0.6
School sites	0.5
Parks and open sandy areas	0.3

4.5.3 Where two drainage systems join as a single system and the Tc for the two systems are not equal, the downstream flow quantity shall be determined from the following formula:

$$Q(3) = Q(1) + Q(2) \times \frac{I(1)}{I(2)} \qquad (4)$$

Where:

Q(1) = Runoff quantity from area with the greater Tc.

Q(2) = Runoff quantity from area with the lesser Tc.

Q(3) = Downstream runoff flow quantity.

I(1) = Rainfall intensity in accordance with SAES-A-112, for area with the greater Tc.

I(2) = Rainfall intensity in accordance with SAES-A-112, for area with the lesser Tc.

4.6 Storm Drain Pipe, Culverts and Open Channel Flow

4.6.1 Storm drain pipe and open channel flow velocities shall be determined from the Manning formula:

$$V = \frac{(r^{2/3}) * (s^{0.5})}{n} \qquad (5)$$

Where:

V = Average velocity in meters per second.

r = Hydraulic radius (cross-sectional area divided by the wetted perimeter) in meters.

s = Hydraulic slope (slope of the pipe or channel) in meters per meter.

n = Roughness coefficient of pipe or channel, given in Table 2 below.

Table 2 – Roughness Coefficient

Surface	n
Vitrified clay or RTR pipe	0.013
Concrete or steel pipe	0.015
Paved streets with curb and gutter	0.015
Concrete lined open channels and box culverts	0.016
Constructed open channels with concrete side slopes	0.019
Constructed open channels with earth side slopes	0.023
Constructed open channels with rip-rap side slopes	0.027
Smooth natural stream channels	0.040
Rough or rocky natural stream channels	0.050

4.6.2 Culverts shall be designed in accordance with AASHTO HDG-3 VOL IV Guidelines for Hydraulic Design of Culverts.

4.6.3 The flow velocity in a storm drain, culvert, or a fully lined open channel shall be not less than 0.9 m/s or more than 3 m/s at peak flow.

4.6.4 The flow velocity shall not be more than 0.76 m/s in constructed open channels without side slope protection, and not more than 1.52 m/s in constructed channels with rip-rap or concrete side slopes.

4.6.5 Piping design flow depth shall not exceed 2/3 of the pipe diameter. Box culverts shall be designed at no less than 50% greater than required by hydraulic calculation.

4.6.6 The minimum diameter of a storm drain pipe (except building connections) or road crossing culvert shall be 300 mm. Branch lines to individual drain inlets shall not be smaller than 200 mm.

4.6.7 The ends of road crossing culverts and the exit of storm drains at an open channel shall have concrete headwalls. The headwalls, as well as the ends of concrete box culverts, shall have a cut-off wall at the entrance or exit lip of not less than 0.6 m below the channel invert.

4.6.8 The maximum spacing between drainage inlets should not exceed 90m.

4.6.9 Manholes are required at the following locations:

a) At changes of horizontal or vertical direction of storm drain pipes.

b) Maximum Spacing of manholes shall be 60m for sewers less than or equal to 300 mm in diameter and 150m for sewers larger than 300 mm in diameter.

4.6.10 Storm drain manholes shall have a minimum inside diameters:

4.6.10.1 1.2 m for straight run manholes with a pipe diameter size of 600 mm or less.

4.6.10.2 1.8 m for straight run manholes for pipes larger than 600 mm diameter.

4.6.10.3 1.8 m for junction manholes.

4.6.11 Lift stations shall be in accordance with SAES-S-010 with the exception that stand-by pumps and alarms are not required.

Commentary Note:

The need for stand-by pumps and alarms shall be determined by the project's risk tolerance for flooding.

4.6.12 Minimum ground cover for piping shall be in accordance with Section 9.12 of SAES-S-070.

4.7 Considerations for Existing Facilities

4.7.1 Existing systems to which new systems will connect shall be reviewed to verify service compatibility and to ensure that sufficient capacity is available to accept the additional flow, unless Saudi Aramco has provided a written notice that the downstream system can accommodate the additional flow.

4.7.2 If construction of new storm drainage systems interfere with existing drainage systems, satisfactory temporary bypass facilities shall be provided.

4.7.3 Open ends of existing storm drainage pipes that are cut or abandoned in place shall be securely closed with a plug or wall of concrete having a minimum thickness of 3 pipe diameters.

4.8 All storm drain systems shall be identified on plant drawings in accordance with SAES-A-100. Locations (coordinates) and elevations shall be shown in the drawings.

5 Materials and Installation

5.1 Materials

5.1.1 Following are the acceptable materials for storm drainage piping.

a) The materials listed in Section 5.1 of SAES-S-020 are acceptable for storm drainage piping.

b) Reinforced concrete pipe, ASTM C76M Class III, Wall B, for pipes 300 mm and larger. Joints shall be sealed using elastomeric "O" rings according to ASTM C443 unless otherwise noted in project specification.

c) Concrete pipe 250 mm and smaller shall be in accordance with ASTM C14 Class III non-reinforced, bell and spigot, or tongue and groove sewer pipe.

d) Corrosion protection shall be in accordance with SAES-S-020.

5.1.2 Rip-rap shall be solid stone or concrete measuring at least 300 mm in all dimensions.

5.2 Installation

5.2.1 Storm drains shall be installed in accordance with SAES-S-070. The piping not covered in SAES-S-070 shall be installed in accordance with the pipe manufacturer's recommendations.

5.2.2 Concrete structures shall be in accordance with SAES-Q-001.

5.2.3 Rip-rap shall be hand laid to provide a tight fit between the individual pieces. The rip-rap shall be solid grouted for a distance of not less than 3 m upstream and downstream of concrete box culverts and along the outside face of all curves plus 3 m upstream and downstream of the curve tangent points. The grout shall be in accordance with SAES-Q-010.

5.3 Testing

The hydrostatic testing of exclusive storm water drainage systems, as specified in Section 18 of SAES-S-070, is not applicable as far as this standard is concerned.

Revision Summary

28 April 2004	Revised the "Next Planned Update". Reaffirmed the contents of the document, and reissued with minor changes.
31 August 2005	Minor revision to clarify piping and culvert design flow depth, add reference to AASHTO Guidelines for Hydraulic design of Culverts, specify maximum spacing of inlets, require the plugging abandoned pipes, and allow use of unreinforced concrete pipe.