ENGINEERING STANDARD

FOR

GEOMETRIC DESIGN OF ROADS AND STREETS

ORIGINAL EDITION

MAR. 1996

This standard specification is reviewed and updated by the relevant technical committee on Dec. 2000(1) and July. 2006(2). The approved modifications are included in the present issue of IPS.

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1. SCOPE

This Engineering Standard deals with different aspects of design principles and data as criteria for the design of roads, streets, sidewalks, and drainage for the Petroleum Industries' projects.

This Standard is written in general terms and its application to any particular project may be subject to the special requirement of the work under consideration.

This Standard also sets out general guidelines for control and supervision of work to produce an economic and safe design.

Note 1:

This standard specification is reviewed and updated by the relevant technical committee on Dec. 2000. The approved modifications by T.C. were sent to IPS users as amendment No. 1 by circular No 134 on Dec. 2000. These modifications are included in the present issue of IPS.

Note 2:

This standard specification is reviewed and updated by the relevant technical committee on July. 2006. The approved modifications by T.C. were sent to IPS users as amendment No. 2 by circular No 295 on July. 2006. These modifications are included in the present issue of IPS.

2. REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

AASHTO **(AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS)**

"A Policy on Geometric Design of Roural Highways" 1965

"A Policy on Design of Urban Highways and Arterial Streets" 1973

IPS **(IRANIAN PETROLEUM STANDARDS)**

IPS-E-GN-100 "Engineering Standard for Units"

IPS-E-CE-110 "Engineering Standard for Soil Engineering"

IPS-G-CE-182 "Engineering and Construction Standard for Road Surfacing and Pavements"

API **(AMERICAN PETROLEUM INSTITUTE)**

API RP 1102 1993 "Steel Pipelines Crossing Railroads and Highway"

3. UNITS

This Standard is based on International System of Units (SI) as Per IPS-E-GN-100, except where otherwise specified.

4. TYPES OF ROAD AND STREET

4.1 Classification of Roads and Streets

Roads and Streets of Iranian Petroleum Industries are classified by location and function as follows:

4.1.1 Location

- Roads are traffic arteries outside of built-up areas.
- Streets are traffic arteries within built-up areas.

4.1.2 Function

a) Major streets or primary roads

The function of these roads or main traffic arteries is to serve or connect the main functional areas of a petroleum installation.

They are capable of carrying the largest volume of traffic and the heaviest types of vehicles anticipated.

b) Secondary streets or secondary roads

These streets or roads supplement the main system by providing access within each functional area. Secondary streets and roads are capable of carrying a moderate volume of medium-weight traffic with the occasional passage of maximum weight vehicles.

c) Lesser streets or tertiary roads

These streets and roads provide for traffic to individual buildings or groups of buildings or patrolling road within functional areas.

They are capable of carrying a moderate volume of light-weight traffic.

5. PRELIMINARY CONSIDERATIONS

Before designing roads and streets of any classification the following factors should be considered.

5.1 General Factors

a) Coordination with the master development plan.

b) Funds available.

c) Topography and physical features of the area.(For more detailed information refer to IPS E-CE-110, "Soil Engineering").

d) Cost of alternative road designs.

e) Climatic conditions.

Special consideration shall be given to design for protection of subgrades and shoulders in typhoon areas.

f) Required life expectancy.

The expectancy must be comparable to the useful life of a served facility. Usually the design year is about 20 years from the date of completion of construction but may range from the current year to 20 years depending on the nature of the improvement.

5.2 Specific Requirements

In addition to the above general factors, the following surveys, studies, and explorations should be conducted, as required:

- Reconnaissance survey
- Preliminary survey
- Location survey
- Traffic estimate
- Weight and size considerations
- Subsurface conditions.

6. DESIGN SPEED

For general information on design speeds, the following preliminary factors should be considered:

a) Streets

A maximum speed of 50 km/h shall be considered as the design speed for all major and secondary streets, even when the posted speed will be considerably less.

b) Roads

A maximum speed of 80 km/h shall be considered as the design speed for all major and secondary roads, even when the posted speed will be considerably less.

7. DESIGN VEHICLES

Two general classes of vehicles have been selected, namely, passenger cars and trucks. The passenger car class includes compacts and subcompacts plus all light vehicles and light delivery trucks (vans and pickups). The truck class includes single-unit trucks, buses, truck tractor-semitrailer combinations, and trucks or truck tractors with semitrailers in combination with full trailers.

The dimensions for two design vehicles representing vehicles within these general classes are given in Table 1. In the design of any highway facility the largest design vehicle likely to use that facility with considerable frequency or a design vehicle with special characteristics that must be taken into account in dimensioning the facility is used to determine the design of such critical features as radii at intersections and radii of turning roadways.

7.1 Minimum Turning Paths of Design Vehicles

The principal dimensions affecting design are the minimum turning radius, the tread width, the wheelbase, and the path of the inner rear tire. Effects of driver characteristics (such as the rate at which the driver approaches centripetal acceleration) and of the slip angles of wheels are minimized by assuming that the speed of the vehicle for the minimum radius (sharpest) turn is less than 16 km/h.

The minimum turning radii and the transition lengths shown are for turns at less than 16 km/h. Higher speeds lengthen the transition curves and require larger radii than the minimums. The dimensions and turning characteristics for passenger car and large semitrailer "Double bottom" are given in Table 1 and Table 2.

TABLE 1 - DESIGN VEHICLE DIMENSIONS

DESIGN VEHICLE TYPE	SYMBOL	DIMENSIONS (m)							
		OVERALL			OVERHANG		WB1*	WB2*
		HEIGHT**	WIDTH	LENGTH	FRONT	REAR		
Passengercarlarge semitrailer "double bottom"	P WB-50	 4.25	2.1 2.6	5.7 16.5	0.9 0.9	1.5 0.6	3.3 6.0	--- 9.0

*** WB1 and WB2, are effective vehicle wheel bases.**

**** Overall height is used as a basis for vertical clearance. Vertical clearance at under passes should be at least 4.10 m over the entire roadway width, to which up to 0.15 m should be added to allow for future resurfacing.**

TABLE 2 - MINIMUM TURNING RADII OF DESIGN VEHICLES

DESIGN VEHICLE TYPE	PASENGER CAR	SEMI TRAILER COMBINATION (LARGE)
Symbol	P	WB-50
Minimum turning radius, (m)	7.3	13.7
Minimum inside radius, (m)	4.66	6.0

8. ELEMENTS OF DESIGN

8.1 Design Related to Vertical Alignment

8.1.1 General

The followings must be carefully considered:

1) Good correlation with horizontal alignment.

2) Provision of adequate sight distance over all crests.

3) Avoidance of very short sag vertical curves.

4) Avoidance of a short grade between two crests or two sag curves.

5) Avoidance of short drop immediately before a long upgrade.

6) Avoidance of the combination of two vertical curves in the same direction (they should normally be placed by a single vertical curve).

8.1.2 Stopping sight distance

This is the distance required for safe vehicle operation, when opposite-direction traffic is not involved in passing operations. The minimum distance should be sufficient at the design speed for perception and brake-reaction time and for bringing the vehicle to a stop. Minimum stopping sight distance for specified design speed should be as shown in Table 3.

TABLE 3 - MINIMUM STOPPING SIGHT DISTANCE

DESIGN SPEED (km/hr)	STOPPING SIGHT DISTANCE (m)
50	65
80	120

8.1.3 Passing sight distance

Passing sight distance is the distance required to allow safe overtaking at design speed in the face of on-coming traffic. The minimum passing sight distance for specified design speed should be as shown in Table 4.

TABLE 4 - MINIMUM STOPPING SIGHT DISTANCE

DESIGN SPEED (km/hr)	STOPPING SIGHT DISTANCE (m)
50	250
80	520

*** Passing sight distance is measured from driver's eye 1.14 m above the pavement to the top of an object 1.37 m on the pavement.**

8.1.4 Minimum length of vertical curve in sags

Minimum length of vertical curve in sag to maintain the safe stopping distances for specified design speeds should be in accordance with Table 5.

TABLE 5 - MINIMUM LENGTH OF VERTICAL CURVES IN SAG

	MINIMUM LENGHT OF VERTICAL CURVE (m)							
DESIGN SPEED (km/hr)	A=2	A=4	A=6	A=8	A=10	A=12	A=14	A=16
30	30	43	63	90	110	132	133	180
80	45	90	140	183	230	273	330	363

A = Algebraic difference in grades, %

8.1.5 Maximum grades and Lengths

Maximum grades and lengths of grades to be used in different class of roads shall be in accordance with Table 6.

TABLE 6 - MAXIMUM GRADES AND GRADE LENGTHS

CLASSIFICATION	MAXIMUM GRADE %	MAXIMUM GRADE LENGTH (m)
Paved road	8	300
Unpaved road	10	200

8.2 Design Related to Horizontal Alignment

8.2.1 Horizontal alignment

In the design of road or street curves it is necessary to establish the proper relation between design speed and curvature and their joint relations with superelevation. Table 7 shows these relations.

TABLE 7 - RELATION BETWEEN DESIGN SPEED AND OTHER ELEMENTS OF HORIZONTAL ALIGNMENT

DESIGN SPEED (km/hr)	MINIMUM RADIUS OF HORIZONTAL CURVE (m)	MINIMUM APPROACH LENGTH FOR SUPERELEVATION (m)	MAXIMUM SUPERELEVATION LIMIT (%)
30	80	40	7
80	220	33	7

8.2.2 Sight distance on horizontal curve

Where there are sight obstructions (such as walls,cut slopes, buildings, and guardrail under certain conditions) on the inside of curves, a design to provide adequate sight distance may require adjustment in the normal road crosssection or change in alignment if the obstruction cannot be removed.

Table 8 shows the required stopping sight distances and lateral clearance to obstruction for specified design speed and radiuses.

TABLE 8 - STOPPING SIGHT DISTANCE ON HORIZONTAL CURVE

DESIGN SPEED (km/hr)	RADIUS OF CURVATURE (m)	LATERAL CLEARANCE (m)	STOPPING SIGHT DISTANCE (m)
30	83	33	60
80	230	33	103

8.2.3 Pavement widening on curves

Pavements on curves are widened to make operating conditions on curves comparable to those on tangents. For curves of less than 170 meter length the widening width should be 500 mm. For curves of more than 170 meter length, the widening of pavement is eliminated.

9. CROSS SECTION ELEMENTS

9.1 Pavement

See IPS-G-CE-182 "Road Surfacing and Pavements" for the design of flexible pavements as well as unpaved roadways.

9.1.1 Crowns or cross slopes

For drainage of pavement, the road surface must have a cross slope. Two-lane pavements on tangent or on flat curves have a crown or high point in the middle and slope downward toward both edges. Where pavements are designed on tangent, the values in the ranges of cross slopes in Table 9 should be used.

TABLE 9 - RATE OF PAVEMENT CROSS SLOPES

SURFACE TYPE	CARRIAGEWAY CROSS SLOPE %	SHOULDER CROSS SLOPE %
Paved road (flexible pavement)	1.5 to 2.5	3
Unpaved road (rig road)	3.5 to 4.5	---

9.2 Road and Street Width

The width to be adopted in the design of roads should be closely related to classification of road. For roads outside of fenced areas the width should be in accordance to Table 10.

9.2.1 Shoulder cross slopes

Shoulders are important links in the lateral drainage systems, to rapidly drain surface water. The amount of shoulder cross slopes are given in Table 10.

TABLE 10 - ROAD WIDTHS

ROAD CLASSIFICATION	CARRIAGEWAY WIDTH (m)	SHOULDER WIDTH AT BOTH SIDES (m)	SHOULDER CROSS-SLOPE (PERCENT)
Asphalt paved primary road	7.5	1.5	4
Asphalt paved secondary road	5.5	0.75	3
Rig road	7	---	---

For streets inside of fenced areas the widths should be in accordance with Table 11.

TABLE 11 - STREET WIDTHS

CARRIAGE WAY WIDTH (m)	SHOULDER WIDTH AT BOTH SIDES (m)
3	0.75
6	0.75
8	0.75

9.3 Erosion Control

Shoulders and side slopes should be adequately protected against erosion by the development of a firm turf growth. This should be accomplished by the use of natural grass under favorable climatic and soil conditions. Shoulders could be stabilized by a light bituminous treatment, if subjected to excessive vehicular usage in dry climatic conditions.

9.4 Drainage

Drainage channels perform the vital function of collecting and conveying surface water from the road right-of-way. Drainage channels, therefore, should have adequate capacity for the design run-off; should provide for unusual storm water with minimum damage to the road, and should be located and sloped to avoid creating a hazard to traffic.

Where the topography of region permits roadside channels built in earth should have side slopes of 4:1 (horizontal to vertical) or flatter, having a rounded bottom with minimum width of 1.2 m.

Rounded slopes of side and ditch bottoms of channels reduce the chance of an errant vehicle becoming airborne, thereby increasing the safety of channels. When saturation of the subgrade is limited, the minimum grade for unpaved channels should be about 0.5 percent. In areas with steep channels, they should be lined.

9.5 Side Slopes

In general, side slopes shall be as flat as possible and rounded to the practicable extent within grading limits.

9.5.1 Design

Side slopes shall be 4:1 or flatter where feasible and not steeper than 2:1, except in rock excavation or other special conditions.

Effective erosion control, low cost maintenance, and adequate drainage of the subgrade largely are dependent on proper shaping of the side slopes. Table 12 shows what kind of slopes are used as a general basis for design of earth side slopes.

TABLE 12 - GUIDE FOR EARTH SIDE SLOPES

HEIGHT OF CUT OR FILL (m)	DESIRABLE EARTH SLOPE, HORIZONTAL TO VERTICAL, FOR TYPE OF TERRAIN		
	FLAT OR ROLLING	MODERATELY STEEP	STEEP
0 - 1.0	6 : 1	4 : 1	4 : 1
1.2 - 3.0	4 : 1	3 : 1	2 : 1
3 - 4.5	3 : 1	5 : 2	7 : 4
4.5 - 6.0	2 : 1	2 : 1	3 : 2*
OVER 6.0	2 : 1	3 : 2*	3 : 2*

*** Slopes 2:1 or steeper should not be used for clay or silty soils.**

10. TRAFFIC CONTROL AND LIGHTING

For detailed information about traffic control devices, and marking and posting roads and streets refer to AASHTO's "A Poliy on Geometric Design of Rural Highways" and IPS-G-CE-182.

10.1 Lighting

Wherever specified by AR* provide roadside lighting at the following critical areas:

- Channelized road intersection and interchanges.
- Pedestrian cross walks.
- Long bridges.

*** AR = Authorized Representative of the Owner.**

- Tunnels and bridges of substantial length.
- Areas with roadside interference.
- Railroad crossings.
- Built-up areas.

10.2 Pole Locations in Open Areas

Pole locations shall be according to the following restrictions:

- Clear of shoulders, 4.5 m or more from the edge of pavement.
- A minimum distance of 3 m. from traffic lanes.
- A minimum distance of 1.8 m from safety curbs.
- Located in median strips where the width is a minimum of 6 m.

10.3 Pole Location in Built-up Areas

Set poles a minimum of 0.6 m from edge of pavement. Poles should be installed outside of shoulder or footpath curb.

10.4 Mounting Heights

Mounting heights shall be a minimum of 7.5 m in open areas, and a minimum of 6.0 m in built-up areas.

10.5 Guardrails

For use of guardrails see AASHTO's "A Policy on Geometric Design of Rural Highways".

11. SIDEWALKS

Justification of sidewalks in rural areas depends upon the volume of pedestrian and vehicular traffic, their relative timing, and the speed of vehicular traffic.

Sidewalks are accepted as integral part of streets, but few are provided in roads.

Sidewalks shall be laid parallel to streets and as walkways to building entrances, and shall be provided in accordance with operational and/or pedestrian traffic requirements. Walkways adjacent to and between buildings, and other facilities in built-up areas, generally are accepted as integral parts of these areas.

a) Walkways

Walkways along roads in open areas, between certain isolated locations, can be as necessary as in built-up areas. The need for walkways should be determined in accordance with the criteria shown in Table 13

TABLE 13 - RELATION BETWEEN PEDESTRIAN AND VEHICULAR TRAFFIC

VEHICULAR TRAFFIC (DHV)	PEDESTRIANS PER DAY WHEN VEHICLE DESIGN SPEED IS
	50-80 (km/h)
Sidewalk, one side:	
30 to 100	150
More than 100	100
Sidewalk, both sides:	
50 to 100	500
More than 100	300

b) Location of sidewalks

Sidewalks shall be set 1.5 m or more back from curb lines, except at parking and unloading areas. For those areas, sidewalks shall be placed adjacent to the curb, and widened as necessary to satisfy operational requirements.

c) Cross slope

Allow 2 percent in the direction of natural drainage.

d) Widths

Allow 0.60 m for each pedestrian traffic lane, with a minimum walk width of 1.2 m. Actual width of walks shall be determined as shown in Table 14.

TABLE 14 - RELATION BETWEEN PEDESTRIAN TRAFFIC AND WIDTH OF SIDEWALK

PEDESTRIANS (PER HOUR)	WIDTH (m)
Up to 100	1.2

The width of a planted strip between the sidewalk and travelway, if provided, should be a minimum of 0.60 m to allow maintenance activities.

e) Grades

The use of steps in walkways shall be avoided, if possible. Single risers, in particular, are hazardous and are prohibited. When steps are required they should have a minimum of three risers. Grade limitations are:

- Minimum allowable: none, flat grades are permissible

- Maximum allowable: 5 percent, however, 6 percent maximum is preferred. Build steps for steeper grade.

f) Ditch crossings

Where sidewalks cross open drainage channel hold the underside of the walkway above the design high water surface.

12. ROAD CROSSING (UTILITIES)

For Detailed information About Road Crossing Utilities Refer to API RP 1102.