
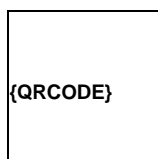
	<p>PROJECT TITLE MARJAN INCREMENT PROGRAM - PKG 10 - GAS TREATMENT & SULFUR RECOVERY</p>		
CONTRACT NO. 6600044609 (OOK) / 6600044610 (IK)	JOB 032242	UNIT T71	
CUSTOMER: ARAMCO OVERSEAS COMPANY B.V.	Doc no.	T71-CA-E-0011041	
PLANT LOCATION: TANAJIB - SAUDI ARABIA	Sh. 1 of 12	Rev. A1	

PROJECT SPECIFICATION FOR RTR BURIED PIPING DESIGN

BI-10-09003



A1	Internal issue	V.Messina	G.Lojacono	G.Lojacono	07/07/2020
Rev.	Description	Prepared	Checked	Approved	Date





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1. SCOPE

The purpose of this specification is to provide to the Vendor the necessary information regarding soil condition, loads, pipe pressures, etc. in order to perform the design of RTR buried pipes for MARJAN PK10 Project.

Specification should be read in conjunction with the attached excel table (attachment 1) which shows piping diameters, working pressures, maximum and minimum elevation of the pipes, dimensions of the trenches.

2. REFERENCE DOCUMENTS

The structural design shall be in conformance with the following industrial codes, standards, and specifications.

Codes and Standard

- AWWA M45 Fiberglass Pipe Design, Third edition
- SAES-S-070 Installation of Utility Piping System, 1 march 2017
- 01-SAMSS-034 RTR (Fiberglass) Pressure Pipe and Fittings, 16/09/17
- 01-SAMSS-029 RTR (Fiberglass) Pipe and Fittings for Gravity Flow, 1/02/15



Project document

- CE-052270 Geotechnical report

Unit of Measurements

The SI units will be used in design, in particular:

- Length m, mm
- Mass kg
- Concentrated force, weight N, kN
- Linear distributed force kN/m
- Surface distributed force kN/m²
- Specific weight kN/m³
- Pressure, stress N/mm²
- Temperature °C

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3. ELEVATIONS AND SOIL COVERS

High point of paving of the plant is set at HPP=+100.000 m

Pipe covers during construction is calculated assuming that the grade elevation is at 99.650 mm (350 mm less than final HPP).

4. CONDITION AND PARAMETERS FOR DESIGN AS PER TABLE 5.7 OF AWWA M45

Reference shall be made to Attachment 1 indicating for each service:

- Diameter
- Maximum and minimum soil cover
- Temperature
- Pressure

4.1. PIPE CHARACTERISTICS

Vendor shall include the pipe characteristics as per Table 5.7 of AWWA M45 in the calculation reports.

4.2. INSTALLATION PARAMETERS & SOIL CHARACTERISTICS

- **Native soil characteristics**

Soil Class II as per the following soil layering reported within geotechnical report doc. CE-052270:





PROJECT TITLE
MARJAN INCREMENT PROGRAM - PKG 10 - GAS TREATMENT & SULFUR
RECOVERY



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Table 13 : Subsurface Formation with Approximate Boundaries

Borehole	Sand Materials	Silt Materials	Cap Rock Materials
	Depth Range (m, bgl)		
BH-101	0.0-20.0	-	-
BH-102	0.0-15.0 16.5-20.0	-	15.0-16.5
BH-103	0.0-13.95 15.0-30.0	-	13.95-15.0
BH-104	0.0-13.95 15.0-30.0	-	13.95-15.0
BH-105	0.0-15.0 16.5-20.0	-	15.0-16.5
BH-106	0.0-15.0	-	15.0-20.0
BH-107	0.0-30.0	-	-
BH-108	0.0-13.5 15.0-20.0	-	13.5-15.0
BH-109	0.0-12.8 15.0-20.0	-	12.8-15.0
BH-110	0.0-16.5 24.0-30.0	16.5-24.0	-
BH-111	0.0-18.0 21.0-25.95 28.5-30.0	-	18.0-21.0 25.95-28.5
BH-112	0.0-20.0	-	-
BH-113	0.0-12.0 13.5-20.0	-	12.0-13.5
BH-114	0.0-10.85 12.8-20.0 21.0-30.0	-	10.85-12.8 20.0-21.0
BH-115	0.0-15.0 16.5-20.0	-	15.0-16.5
BH-116	0.0-14.0 15.0-20.0	-	14.0-15.0
BH-117	0.0-27.15 0.0-13.85 15.0-19.85 21.0-30.0	-	27.15-30.0 13.85-15.0 19.85-21.0
BH-119	0.0-12.6 13.5-20.0	-	12.6-13.5
BH-120	0.0-20.0	-	-
BH-121	0.0-14.0 15.0-30.0	-	14.0-15.0
BH-122	0.0-13.5 15.0-18.45 19.5-20.0	-	13.5-15.0 18.45-19.5
BH-123	0.0-20.0	-	-
BH-124	0.0-13.5 15.0-20.0	-	13.5-15.0
BH-125	0.0-20.0	-	-
BH-126	0.0-16.5 19.5-20.0	16.5-19.5	-
BH-127	0.0-16.5 18.0-19.5 21.0-30.0	16.5-18.0	19.5-21.0
BH-128	0.0-20.0	-	-
BH-129	0.0-12.0 13.5-22.5 24.0-30.0	12.0-13.5	22.5-24.0
BH-130	0.0-27.45 28.5-30.0	-	27.45-28.5
BH-131	0.0-14.0 15.0-20.0	-	14.0-15.0

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Borehole	Sand Materials	Silt Materials	Cap Rock Materials
	Depth Range (m, bgl)		
BH-132	0.0-7.5 9.0-31.5 33.0-40.0	-	7.5-9.0 31.5-33.0
BH-133	0.0-7.95 9.0-18.45 19.5-25.95 27.0-30.0	-	7.95-9.0 18.45-19.5 25.95-27.0
BH-134	0.0-8.0 9.0-24.0 25.5-30.0	-	8.0-9.0 24.0-25.5
BH-135	0.0-15.0 18.0-20.0	15.0-18.0	-
BH-136	0.0-20.0 22.5-30.0	-	20.0-22.5
BH-137	0.0-20.0	-	-
BH-138	0.0-33.0 34.5-40.0	-	33.0-34.5
BH-139	0.0-22.5 24-30.0	-	22.5-24.0
BH-140	0.0-14.0 15.0-30.0	-	14.0-15.0
BH-141	0.0-13.95 15.0-20.0	-	13.95-15.0
BH-142	0.0-27.0	-	27.0-30.0
BH-143	0.0-20.0	-	-
BH-144	0.0-27.0 28.5-33.0 35.5-40.0	-	27.0-28.5 33.0-35.5
BH-145	0.0-13.8 15.0-30.0	-	13.8-15.0
BH-146	0.0-15.7 18.5-30.0	-	15.7-18.5
BH-147	0.0-12.5 13.5-18.5 18.0-20.0	18.5-18.0	12.5-13.5
BH-148	0.0-20.0	-	-
BH-149	0.0-13.95 15.0-18.5 19.5-20.0	-	13.95-15.0 18.5-19.5
BH-150	0.0-20.0	-	-
BH-151	0.0-20.0	-	-
BH-152	0.0-20.0	-	-
BH-153	0.0-20.0	-	-
BH-154	0.0-20.0	-	-
BH-155	0.0-20.0	-	-
BH-156	0.0-20.0	-	-
BH-157	0.0-20.0	-	-
BH-158	0.0-12.0 13.5-20.0	-	12.0-13.5
BH-159	0.0-20.0	-	-
BH-160	0.0-20.0	-	-



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Table 6-1 Soil classes

Soil Classes	Unified Soil Classification System Soil Groups*	American Association of State Highway and Transportation Officials (AASHTO) Soil Groups†
Class I	Crushed rock: ≤ 15% sand, maximum 25% passing the ¾-in. sieve and maximum 5% passing No. 200 sieve‡	
Class II	Clean, coarse-grained soils: SW, SP, GW, GP, or any soil beginning with one of these symbols with 12% or less passing No. 200 sieve§	A1, A3
Class III	Coarse-grained soils with fines: GM, GC, SM, SC, or any soil beginning with one of these symbols with more than 12% fines Sandy or gravelly fine-grained soils: CL, ML (or CL-ML, CL/ML, ML/CL) with more than 30% retained on a No. 200 sieve	A-2-4, A-2-5, A-2-6, or A-4 or A-6 soils with more than 30% retained on a No. 200 sieve
Class IV	Fine-grained soils: CL, ML (or CL-ML, CL/ML, ML/CL) with 30% or less retained on a No. 200 sieve	A-2-7, or A-4 or A-6 soils with 30% or less retained on a No. 200 sieve
Class V	Highly plastic and organic soils: MH, CH, OL, OH, PT	A5, A7

NOTES:

* ASTM D2487, Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).

† AASHTO M145, Classification of Soils and Soil Aggregate Mixtures.

‡ Class I soils have higher stiffness than Class II soils, but data on specific soil stiffness values are not available at the current time. Until such data are available, the soil stiffness of placed, uncompacted Class I soils can be taken to be equivalent to Class II soils compacted to 95% of maximum Standard Proctor Density (SPD 95), and the soil stiffness of compacted Class I soils can be taken to be equivalent to Class II soils compacted to 100% of maximum Standard Proctor Density (SPD 100). Even if placed, uncompacted (i.e., dumped), Class I materials should always be worked into the haunch zone to assure complete placement, see Sec. 6.7.3.

Crushed rock is defined as angular and subangular per ASTM D2488 and D5821.

§ Uniform fine sands (SP) with more than 50% passing a No. 100 sieve (0.006 in., 0.15 mm) are very sensitive to moisture and should not be used as backfill for fiberglass pipe unless specifically allowed in the contract documents. If use of these materials is allowed, compaction and handling procedures should follow the guidelines for Class III materials.

- Constrained modulus of the native soil at pipe elevation**



$M_{sn} = 20.7 \text{ MPa}$ as per the below table:

Table 5-6 Values for the constrained modulus of the native soil at pipe zone elevation

Native in Situ Soils*						
Granular		Cohesive			M_{sn}	
Blows/ft* (0.3 m)	Description	q_u				
		tons/sf	kPa	Description	psi	MPa
> 0-1	very, very loose	> 0-0.125	0-13	very, very soft	50	0.34
1-2	very loose	0.125-0.25	13-25	very soft	200	1.4
2-4		0.25-0.50	25-50	soft	700	4.8
4-8	loose	0.50-1.0	50-100	medium	1,500	10.3
8-15	slightly compact	1.0-2.0	100-200	stiff	3,000	20.7

- Constrained modulus of the pipe zone embedment**

The clean sand from the bottom of the pipe to 300 mm above the top of the pipe (sand cover) shall be compacted by water flooding and hand tamping only. Backfill above 300 mm sand cover shall be compacted as follows:

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Non-traffic Areas	Traffic Areas
70% relative density per ASTM D4253/ASTM D4254	85% relative density per ASTM D4253/ASTM D4254
or	or
90% of maximum density per ASTM D698	95% of maximum density per ASTM D1557

The following parameter shall be assumed for the design:

Soil Class II

The Vendor shall select the constrained soil modulus within the value of the column Soil Class II SPD 90.

Table 5-4 M_{sb} based on soil type and compaction condition (see chapter 6) (continued)

Vertical Stress Level (see note 5)	Depth for Soil Density = 18.8 kN/m ³	Metric Units			
		Soil Class I and Class II			
		SPD 100	SPD 95	SPD 90	SPD 85
		MPa	MPa	MPa	MPa
6.9	0.4	16.2	13.8	8.8	3.2
34.5	1.8	23.8	17.9	10.3	3.6
69	3.7	29	20.7	11.2	3.9
138	7.3	37.9	23.8	12.4	4.5
276	14.6	51.7	29.3	14.5	5.7
414	22	64.1	34.5	17.2	6.9

- **Shape factor**

The Vendor shall select shape factor within the value of the last column (Sand \geq 85% SPD).

Table 5-1 Shape factors D_f

Pipe Stiffness	Pipe-Zone Embedment Material and Compaction			
	Gravel*		Sand*	
	< 85% SPD†	\geq 85% SPD‡	< 85% SPD†	\geq 85% SPD‡
	Shape Factor D_f (dimensionless)			
psi	kPa			
9	62	5.5	7.0	6.0
18	124	4.5	5.5	5.0
36	248	3.8	4.5	4.0
72	496	3.3	3.8	3.5

* GW, GP, GW-GC, GW-GM, GP-GC, and GP-GM per ASTM D2487 (includes crushed rock).



† SW, SP, SM, SC, GM, and GC or mixtures per ASTM D2487.

‡ < 85% standard Proctor density (ASTM D698), < 40% relative density (ASTM D4253 and D4254).

§ \geq 85% standard Proctor density (ASTM D698), \geq 40% relative density (ASTM D4253 and D4254).

- **Water table**

No water table shall be considered in the design.

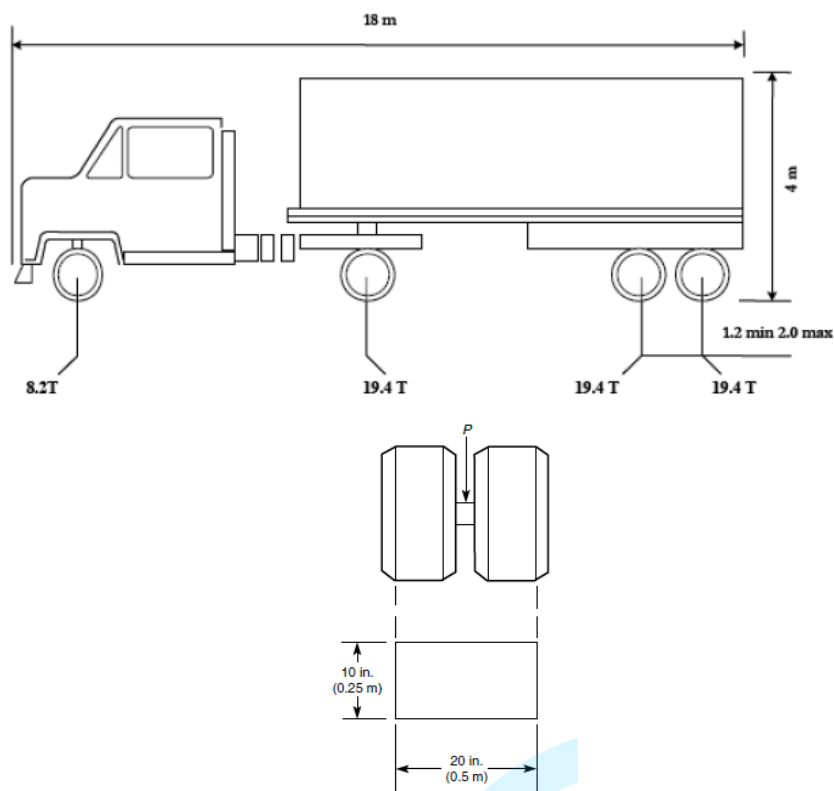
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5. LOADING CONDITIONS

Vendor shall perform analysis for the following loading conditions:

1) AR-40 truck, as per SAES-S-070 §9.12 (OPERATION PHASE)



The design wheel load is 9.7 metric tons (19.4 ton/axle). AR-40 applies to main thoroughfares and government highways.



Vendor shall carry out the check for the following elevations only considering that max allowable deflection shall be less than 5%, unless more stringent value is recommended by Manufacturer.

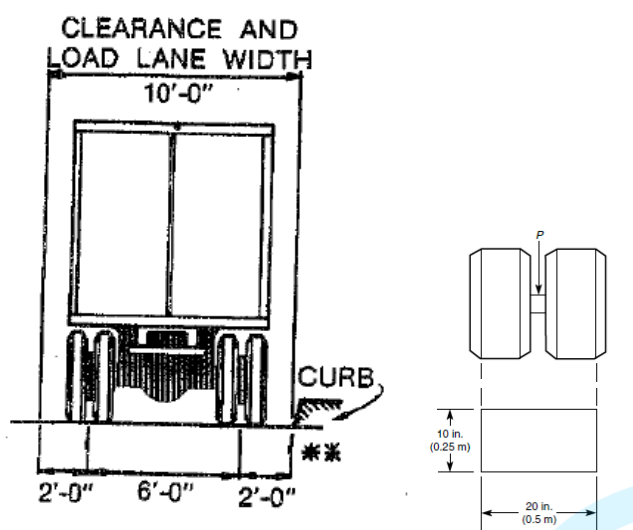
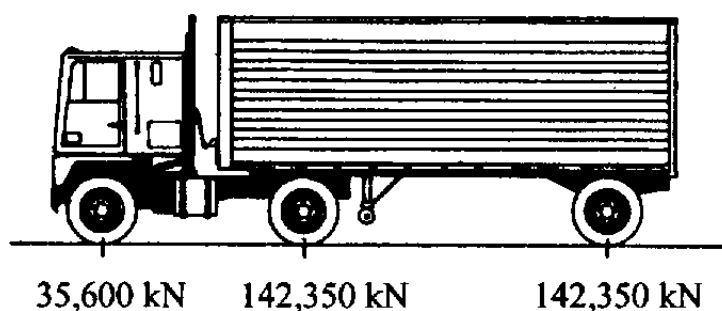
Cover over Top of Pipe

Type of Pipe	Nominal Pipe Size and Service	Minimum Cover (mm)
RTR	Under 150 mm size	600
RTR	150 mm and larger	900

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2) HS-20 truck (OPERATION PHASE)

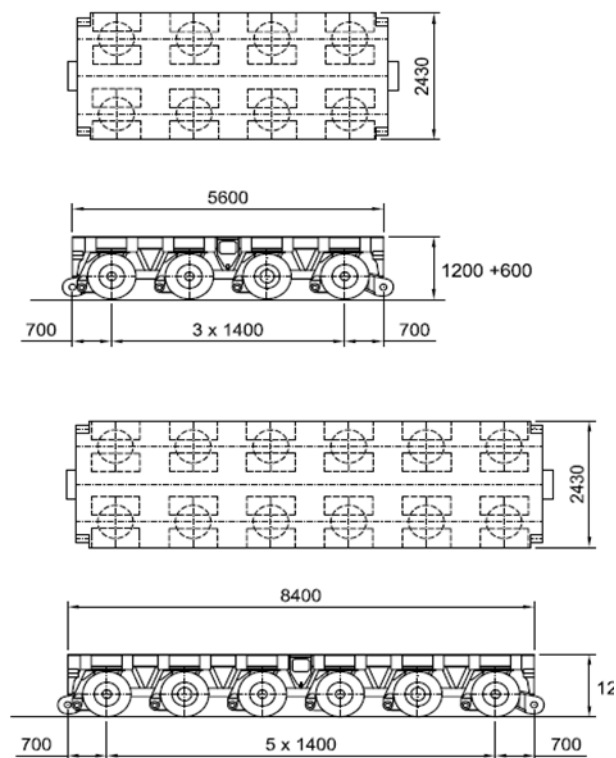
Vendor shall carry out the calculation considering the pipe maximum and minimum burial depth provided in the Attachment 1 by CONTRACTOR.



3) SPMT 31 ton/axle (DURING CONSTRUCTION)

Vendor shall carry out the calculation considering the pipe maximum and minimum burial depth provided in the Attachment 1 by CONTRACTOR.

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4) Crawler cranes (DURING CONSTRUCTION)

Vendor shall carry out the calculation considering the pipe maximum and minimum burial depth provided in the Attachment 1 by CONTRACTOR.



load case	Crane TAG	pressure	crawler+MAT dimensions
1	Crane 1250	30 ton/m2	16x5.5
2	Crane 600	20 ton/m2	12x5

6. ANALYSIS OF RESULTS

Vendor shall carry out the analysis as per burial depth described in Attachment 1.

Following cases may result:

- a) For a specific diameter, the line is verified both for minimum and maximum burial depth → NO FURTHER ACTION REQUIRED

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- b) For a specific diameter, the line is NOT verified both for minimum and maximum burial depth → NO FURTHER ACTION REQUIRED
- c) For a specific diameter, the line is NOT verified for minimum burial depth but it verified for maximum burial depth → **Vendor is requested to vary the MINIMUM burial depth only up to identify the shallowest value of minimum burial depth for which the check is verified. Refer to sketch below for clarification. The modified value shall be red colored in the calculation report.**

