GUIDLINES FOR THE DESIGN OF POTABLE WATER DISTRIBUTION NETWORKS IN AL AIN REGION

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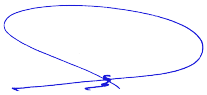
Reviewed By	Abdullah Salem Al Dhaheri	**Water Planning & Development Department Manager**	
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1. REVISION LOG SHEET

All revisions to this IMS Road Map shall be recorded in this Revision Log Sheet. Each time a revision is recorded, the Revision Log Sheet's control No. will be revised accordingly. The obsolete pages of the IMS Road Map shall be removed, destroyed and replaced by the revised pages. The Obsolete Revision Log Sheet shall also be treated as above.
Latest revisions shall be highlighted.

Revision No.	Date	Revision Details	Authorized Signature
01	01/01/2023	Revisions and modifications are introduced to the previous version (version 0) to improve AADC design standards and to comply with the recent changes in TAQA and AADC design standards.	

2. TERMS, ABBREVIATIONS AND DEFINITIONS

- AACM : Al Ain City Municipality
- AMD : Asset Management Directorate, AADC
- B of Q : Bill of Quantities
- CPD : Capital Projects Directorate, AADC
- CSD : Customer Services Directorate, AADC
- DI : Ductile Iron
- Dia. : Diameter
- DMA : District Metered Area
- DN : Diameter Nominal
- DOE : Department of Energy
- DOT : Department of Transport, Abu Dhabi
- EWEC : Emirates Water and Electricity Company
- HDPE : High Density Polyethylene
- MDPE : Medium Density Polyethylene
- PEA : Allowable Maximum Test Pressure at Site
- PFA : Allowable Maximum Operating Pressure without Surge
- PMA : Allowable Maximum Operating Pressure including Surge
- PN : Nominal Pressure (French)
- SDR : Standard Diameter Ratio
- TPD : Town Planning Department, Al Ain City Municipality
- TRANSCO : Abu Dhabi Transmission & Dispatch Company
- UPC : Abu Dhabi Urban Planning Council
- WDC : Water Distribution Code
- WNP&DD : Water Network Planning & Development Department, AMD, AADC

3. PROCESS FLOW CHART

NA

4. OH&S RISK AND OPPORTUNITIES ASSESSMENT

DOCUMENT NAME	DOCUMENT REFERENCE NO.
HSE Risk Management (AMD)	RR.HSEMS.01

5. ENVIRONMENTAL ASPECT & IMPACT ASSESSMENT

DOCUMENT NAME	DOCUMENT REFERENCE NO.
Environmental Management Procedure	CP.HSEMS.15

6. PROCESS EXECUTION TEAM & RESPONSIBILITIES

ROLES	RESPONSIBILITY
NA	NA

7. APPLICABLE LEGAL & OTHER REQUIREMENTS

DOCUMENT NAME	DOCUMENT REFERENCE NO.
HSE Legal Compliance	CP.HSEMS.03

8. METHODOLOGY

8.1 Introduction

The purpose of this design guideline is to establish uniform procedure for the design of distribution networks for potable water in Al Ain Region complying with the DOE requirements, TAQA, AADC standards and the best engineering practice in water supply industry.

These design guidelines gathered and summarized the applied design standards and sources in one document and provided further details to the DOE requirements and TAQA standards, however this document is not substituting these sources nor depriving the designer from referring to these sources and their amendments. The designer shall obtain and apply the requirements of the latest versions of the documents referred to in this document.

The relevant legislation and regulations applied in Abu Dhabi Emirate and UAE including legislated standards and regulations such as DOE requirements takes precedence over this Design Guidelines and shall be followed.

8.2 Applied Standards and Design Approaches

The designers of distribution systems for potable water in Al Ain region are responsible to understand and to incorporate all the relevant government requirements for the planning, design, construction and operation of the potable water system that may impact the design consideration.

The design of water distribution works in Al Ain region shall be carried out by a designer (i.e. Consulting Engineering Companies) approved by TAQA for performing such works and obtained the required TAQA registrations.

The detailed design and tender document shall comply with the current TAQA and AADC design standards and practices such as Standards Specifications, Standard Detail Drawings, etc..

All the construction works at site shall be carried out by Contractors and Sub-Contractors approved by TAQA for carrying out such works.

All the material specified and used in potable water projects shall be from suppliers approved for such works and listed in TAQA approved vendor list.

The main resources for the design of distribution networks in Al Ain Region shall be the following documents with their latest amendments: -

- This document “Guidelines for the Design of Potable Water Distribution Networks in Al Ain Region”
- The Water Distribution Code (WDC), published by the DOE.
- Guide to Water Supply Regulations, published by the DOE
- TAQA Standard Specifications for Water Works which include Technical Data Sheets, Standard Detail Drawings, Template for the Bill of Quantities.
- EWEC and AADC water demand forecast criteria and demand estimates.
- AADC Standard Detail Drawings for Water Works

- AADC Particular Specifications for Water Works
- AADC Templates for the Bill of Quantities for Water Works
- The relevant planning standards and planning documents issued in Abu Dhabi Emirates and UAE such as by UPC, Al Ain City Municipality, etc.
- The relevant laws, regulations and other statutory requirements applied in Abu Dhabi Emirates and UAE such as by AACM, UPC, Civil Defence, etc.
- The relevant International Standards such as ISO and EN BS particularly the standards referred to in TAQA and AADC specifications.
- The practice applied by TAQA and AADC for the design and construction of the potable water works in Abu Dhabi Emirates.
- The best engineering practice applied locally and internationally for the design of water supply systems

The designer shall obtain and apply the requirements of the latest versions of the above listed documents and the other documents referred to in this Design Guidelines or in the relevant design standards.

8.3 Project Design Stages and Deliverables

8.3.1 Design Stages and Deliverables

Unless otherwise specified, the design of the water distribution networks shall be carried out in three main stages as follows:-

1. Preliminary Design Stage

The preliminary design stage shall discuss the proposed design criteria and design assumption, the collected data and findings, provide preliminary design for the proposed schemes and evaluate the possible design options. A Preliminary Design Report shall be submitted covering the following topics:-

- Scope of works, objectives of the project and project area
- Design period of the project
- Proposed design criteria and design assumption.
- Water demand calculations
- The findings from the performed data collection and investigations
- Possible design options with technical and financial evaluation of different options and recommendations for the option to be applied.
- Surveying and investigations (as applicable).
- Hydraulic analysis using suitable software.
- Layout of the proposed networks showing the tapping points to AADC system, material, route and sizes of pipeline, DMA boundaries, DMA feeding points, required pressure and flow at tapping points.
- Cost estimate for the proposed options in sufficient details.
- Time frame for project design and construction stages and phases.
- Risk analysis
- Application of suitable Optimized Decision Making (ODM) tools such as Whole Life Cycle Analysis to evaluate the possible design options (as applicable).

The Masterplans for new Developments shall be approved by the concerned authorities before proceeding to the design stage of the water projects for these Developments.

The water demand estimates for the new water projects shall be submitted and approved by AADC prior proceeding to the preliminary design stage of the water projects.

2. Detailed Design Stage

After AADC approval of the preliminary design stage the designer shall proceed to the detailed design stage and shall submit a detailed design report.

The detailed design report shall discuss in more details the topics discussed in the preliminary design report with more concentration on the design option to be applied. Also, the report shall incorporate AADC comments on the previous design stages. This shall include: -

- Discuss in more details (as applicable) the topics covered in the preliminary design stage.
- Incorporation of the received comments on the previous design stages
- Discuss the design option to be applied in more details.
- Detailed hydraulic analysis using suitable software
- Layout drawings for the proposed water networks including location of chambers and other water facilities, road crossings, location of protection to pipelines, location of DMAs feeding points and boundaries of DMAs.
- Pipeline profile (as applicable)
- Standard detail drawings.
- Structural calculations for buildings, water facilities such as chambers and structures (as applicable), etc.
- Detailed cost estimate
- Identification and assessment of associated risks and risk treatment
- Value engineering assessment (as applicable)

3. Tender Document

A typical tender document for water projects shall include 5 volumes as follows: -
If the designer scope not include preparation of Tender Document such as for the projects designed for third party (i.e. Real Estate Developers, etc..), the designer shall submit a construction document including most of the parts covered in the tender document and shall clearly specify the works to be constructed to enable proper supervision of the construction stage.

Volume 1 of Tender Document : Conditions of Contract (hard + soft format)

The Conditions of Contract shall be prepared by using the latest AADC template and format for Volume 1 of tender documents. Soft copy of Volume 1 template can be collected from AADC.

Volume 2 of Tender Document: Specifications

- TAQA standard specifications (soft copy only).
- Particular specifications (hard + soft copies): AADC Particular Specifications plus any additional Particular Specifications prepared by the designer for the project.

- TAQA Technical Data Sheets (hard + soft copies) after filling the fields to be specified by the designer.
- TAQA Approved Vendor List for suppliers (soft copy only). Latest copy can be collected from AADC.

Volume 3 of Tender Document: Bill of Quantities (hard + soft format)

- Preamble to Bill of Quantities
- Bill of Quantities

The Preamble and the B of Q may be based on TAQA Preamble and B of Q that included in TAQA standard specifications and on AADC templates for Preamble and B of Q for water works.

Volume 4 of Tender Document: Tender drawings (hard + soft format)

- List of drawings
- Project area and key map for layout drawings
- Layout of water networks
- Profile of Pipelines (for sizes 300 mm and above or as required by AADC)
- Standard detail drawings.

The tender drawings shall be based on TAQA standard detail drawings for water works that included in TAQA standard specifications and on AADC Standard detail drawings.

Volume 5 of Tender Document: Health and Safety, Quality Manual (hard + soft format)
Volume 5 shall be prepared by using TAQA/AADC template and format for Volume 5. Soft copy of Volume 5 template can be collected from AADC

8.3.2 Whole-Life Cycle Cost Analyses (WLCCA).

When considering different design options, the designer shall demonstrate that his preferred options are the most economic through undertaking Whole-Life Cycle Cost Analyses (WLCCA).

WLCCA can be used to determine the planning horizons and the appropriate phasing of the project taking into account the growth in demand and changing the operation conditions. Also WLCCA shall be used to size of main pumping pipelines in conjunction with their associated pumping stations to determine the most economical dimeters for pipelines and the associated pumping capacity.

The designer shall use the discount interest rate recommended by the DOE for whole-life costing.

8.3.3 Other Requirements During the Design and Construction Stage.

- The designer shall obtain the required approval for the design stage form AADC and from other concerned authorities such as UPC (i.e. for pipeline route), Al Ain City Municipality, Civil Defence, etc.
- The main design documents such as design reports and tender documents shall be submitted for AADC review and approval, revised versions incorporating AADC comments may be submitted if requested by AADC.
- After the completion of the design stage the designer shall submit the layout of pipeline in CAD format suitable for incorporation in AADC GIS system.

- After completing the construction works As Built Drawings, Operation & Maintenance Manuals and Asset Capitalization of the final B of Q shall be submitted to AADC as per TAQA/AADC procedure and requirements.
- Further design documents may be submitted, also site visits and investigations, data collection, regular meetings with AADC may be carried out as required during the different design stages

8.3.4 Data Provided by AADC

AADC may provide or propose upon request from the designer the following details for the design of potable water schemes: -

- Layout of the existing and proposed AADC water networks including the DMAs within and adjacent to the project area and the status of the pipeline and DMAs (i.e. proposed, active, abandon, etc..). The layout will be provided in printout or soft abstract from TAQA GIS.
- Propose in coordination with the designer the possible tapping point(s) to AADC system and provide the required details at the tapping point(s).
- Propose in coordination with the designer the DMA(s) boundaries and feeding points at the project area and the residual pressure upstream the DMA(s) feeding points.
- Hydraulic details at the tapping points to AADC system such as checking the adequacy of AADC system to supply the required demand from the proposed tapping points and the associated residual pressure at the tapping points.
- Any other details of AADC water system or AADC design requirements such as the SCADA and CPC details and requirements, etc..
- Templates for volume 1 and 5 of the Tender Document.
- AADC particular specifications and AADC standard details drawings for water works which supplement and complete TAQA specifications and TAQA standard drawings.
- TAQA standard specifications. The qualified designers by TAQA have access (online access) to TAQA standard specification.
- Latest copy of TAQA/AADC approved vendors lists

8.3.5 Data to be Collected From Other Authorities

- Masterplan and base maps of the project area showing as minimum the layout of plots and roads in UAE coordinates, etc..
- Existing and proposed finished ground levels at the project area. AADC may provide the ground levels developed by AADC for Al Ain region hydraulic model
- Layout of existing services at project area.
- Other data (if required) such as topographic survey stations, population forecast data, etc..

8.4 TAQA Standard Specifications and AADC Particular Specifications

TAQA standard specifications for water works shall be used without any change as standard specifications for all water works in Al Ain region. The Consultants and the Contractors registered with TAQA are provided with online access to download the latest version of TAQA standard specifications in non-editable format (PDF).

AADC developed Particular Specifications for water works to complete TAQA specifications and to be used in conjunction with it. The designer shall collect copy of AADC particular specifications and shall use it without any change.

The designer may develop additional particular specifications for the proposed details not covered in TAQA and AADC specifications, however he shall notify and obtain AADC approval for any details not comply fully with TAQA/AADC specifications. Moreover, he shall not use the additional particular specifications for any other water project in Al Ain Region without AADC approval.

8.5 TAQA Standard Drawings and AADC Standard Drawings

The standard detail drawings included in TAQA standard specifications for water works (Volume 6) and AADC Standard Detail Drawings for water works shall be used without changes as standard drawings for the water projects.

The designer shall prepare additional standard drawing for the details not covered in TAQA and AADC standard drawings or if he proposes different details. The designer shall notify and obtain AADC approval for any details proposed by him that are not fully comply with TAQA and AADC Standard Detail Drawings. The additional standard drawings developed by the designer shall not be used for any other water project in Al Ain Region without AADC approval.

8.6 TAQA Standard B of Q and AADC Templates for the B of Q

TAQA standard Preamble and Bill of Quantities for water works (included in TAQA standard specifications) and AADC Bill of Quantities templates for water works may be used by the designer as guide for preparing the Preamble and the Bill of Quantities for water projects in Al Ain Region. Also the designer may be requested to use AADC templates for the Preamble and the B of Q for designing AADC water projects.

8.7 Water Projects Designed for Third Party

All the potable water projects designed for third parties such as for Real Estate Developer, etc. shall be reviewed and approved by AADC. Also, the design shall comply with TAQA and AADC requirements and shall be carried out by a designer (Consultant) registered with TAQA for carrying out the design of similar works.

The tender document for potable water works prepared by third parties as part of a tender document for infrastructure and buildings works shall include separate volumes for parts 2, 3 and 4 for water works based on the templates of AADC standard tender document. The relevant contents and requirements stated in Volumes 1 and 5 of AADC standard tender document may be included in the tender documents prepared by the Third Parties for all works.

Immediately after commencing the construction stage the Third Party (i.e. Developer, etc..) in coordination with his designer or contractor shall compile the parts related to the potable water works in the Contract Documents in a separate Contract Document for water works and shall submit it to AADC to use it in the supervision of the construction stage.

The Developer shall notify AADC and shall obtain its approval for any change introduced during the Tendering or the Construction stage to the design works approved by AADC during the design stage.

8.8 Construction Supervision of Water Projects

All the water works constructed for AADC or constructed by third party but it's ownership or operation may be handed over to AADC in future shall be overseen / supervised by AADC during the construction stages. The AADC overseeing / supervision during the construction stage will be managed by the Capital Projects Directorate, AADC.

The design and construction of this works shall be carried out by contractors and consultants registered with TAQA for carrying out similar works. Also, the construction supervision shall be carried out by consulting companies registered with TAQA for similar works.

All the construction works shall be performed according to TAQA specifications and requirements. The material used shall be procured from suppliers approved by TAQA and listed in the approved vendor list for supplying such items.

Any considerable change in design works during the construction stage shall be approved by the Asset Management Directorate (AMD), AADC, however the changes shall be raised to the Capital Projects Directorate (CPD) who shall evaluate and forward it to AMD if needed. Minor design changes that not affect the design concept or the hydraulics of the water networks may be reviewed and approved by the CPD.

8.9 Design Period and Working Life of New Assets

In general, the water distribution networks shall be sized to cover the projected water demand for 20 years period and for physical working life of 50 years before replacement. Hence, suitable material and coating for the pipelines shall be selected for the considered project to achieve 50 years working life. Also, the distribution networks shall be designed assuming 100 % development of the project area and 100 % population occupancy rate within the project area.

The physical working life of the different water facilities before replacement shall be as follows :-

- Pipelines : 50 years
- Civil works : 50 years
- Electrical and Mechanical works : 15 to 35 years according to type, manufacturer recommendations and best engineering practice.
- Instrumentation and SCADA works: 5 to 15 years

8.10 Water Demand

The water demand for new development shall be approved by AADC before proceeding to the preliminary design stage of new water projects. The submission for water demand approval shall include the assumptions used to estimate the demand forecast with breakdown of the calculated demand.

It is recommended to estimate the demand according to following demand categories applied by EWEC /AADC: -

- Domestic demand for villa, shabia, townhouse and apartment
- Domestic landscape demand for villa, shabia and townhouse
- Palaces demand (if applicable)

- Irrigation demand (if applicable)
- Other non- domestic demands (military, industry, institutional, etc)
- Non Revenue Water (NRW). The design shall be carried out for a target NRW rate of 10 % of the average water demand.

The DOE recommended a demand estimate criteria in the "Guide to Water Supply Regulations-Version 2017 " for calculating the size of customer storage tanks and for sizing the service connections. In the absence of accurate demand data the latest version of this criteria may be used to estimate the water demand for new water projects. The DOE demand criteria is shown below.

Table 1 Demand Criteria Recommended by the DOE

Type of Premises & consumption Categories	Description	Estimates of daily rate of Consumption (imperial gallons)	Rounded estimates of daily rate of Consumption (litres)
Hotel (1)	per one bed	100-150	450-675
Car wash station (CWS)	Per manual channel	800	3600
Car wash station (CWS)	Per Automatic channel	2400	10800
Hospital	Hospital (per one bed)	150	675
Day Clinic	Per medical Practitioner	100	450
Day Clinic (with dental)	Per medical Practitioner	150	675
Common market	per square metre	1.1	5
Mosques <300 m^2	per square meter	5.5	25
Mosques > 300 m^2	per square meter	3.5	16
Female Praying Room	per square meter	2	9
Workers Housing	per capita	44	200
Public toilets	per sanitary piece	35-50	160-225
Schools / Universities	per student	5 / 10	25/45
Hostel	per student	44	200
Villa and shabiat	per capita	77	350
Villa / shabiat	Per small service block	250	1100
Villa / shabiat	Per large service block	450	2000
Villa / shabiat	Per external Majlis	150	675
Villa / shabiat	Per maid's room	50	225
Villa / shabiat	Per guard room	100	450
Villa / shabiat (2)	Per bedroom	110	500
Villa / shabiat	Swimming pool/m^2	4-5	18-22
General Services (3)	Per plot square metre	0.2	0.9
Services in a building	up to 5 floors	165	750
Services in a building	from 6 to 10 floors	330	1500
Services in a building (4)	above 10 floors	660	3000
Offices & shops 5	per sanitary piece	35-50	160-225
Offices & shops	per square metre	1	4.5
Restaurants	Per meal	2	9

Offices & shops	per person	10	45
Residential flat	Studio	100	450
Residential flat	1 bedroom	120	550
Residential flat	2 bedrooms	180	820
Residential flat	3 bedrooms	220	1000
Residential flat	4 bedrooms	280	1250
Residential flat	5 bedrooms	350	1600
Residential flat	Per maid's room	50	225
Residential flat	per capita	50	225

Source: Table 1.1, Guide to Water Supply Regulations, Version 2017, DOE

***Notes**: (notes are abstracted from Table 1.1, Guide to Water Supply Regulations, 2017, DOE)*

1. *Hotel category up to 5 stars. Hotels/resorts above 5 stars will be subject to assessment.*
2. *For the shabiat and villa category, a reduction factor may be applied for every additional bedroom according to the Distribution Company's own criteria.*
3. *General services' means water used for internal gardening and general cleaning purposes for a standard-size shabiat and villa.*
4. *Rates of consumption for buildings higher than 20 floors shall be adjusted proportionally.*
5. *All consumption rates for sanitary pieces shall be calculated based on water efficient plumbing fittings as required by ESTIDAMA.*

Note (a): Water consumption rates for other uses, e.g. swimming pools and cooling services, shall be determined following consultation with the Distribution Company.

Note (b): For some of the categories, the Responsible Person has a choice of consumption rate which is subject to the Distribution Company must approval .

8.11 Peak and Minimum Demand Factors

The AADC and EWEC demand forecast figures represent the average day peak month demand (i.e. average day of peak month demand).

For the intermittent supply the distribution networks shall be designed for the peak day demand based on the supply hours per day.

In the absence of accurate data, the following peak and minimum demand factors shall be applied for the design of the water distribution networks.

Table 2: Peak and Minimum Demand Factors

Demand	***Peak Factor***	***Minimum Factor***	***Remarks***
Average Demand	1.00	1.00	Total yearly demand divided by 365 days
Peak/ Minimum Month Demand	1.10 to 1.20	0.85 to 0.95	

Peak/ Minimum Week Demand	1.20 to 1.40	0.80 to 0.90	
Peak/Minimum Day Demand	1.25 to 1.50	0.75 to 0.85	
Peak/Minimum Hour demand or instantaneous demand	1.50 to 3.00	0.30 to 0.50	

Typically, the water pipelines downstream the storage facilities shall be designed for peak hour demand and the water pipelines upstream the storage facilities shall be designed for peak day or peak month demand. The storage facility shall have sufficient capacity to tackle the demand fluctuation during the day.

Following the DOE recommendations, the water distribution networks in Abu Dhabi Emirates shall be designed for the peak day demand due to the presence of customers tanks of sufficient capacity to tackle the demand fluctuation during the day. Also, it may be requested by AADC in some cases, to design the networks upstream the storage facilities (customer's tanks) for peak month demand.

In the absence of customers tanks or if the tank capacity is not sufficient to tackle the demand fluctuation during the day, the water networks shall be designed for suitable peak hour demand factor considering the available storage capacity at the customer tank.

8.12 Head Losses in Networks and Friction Coefficient

The water distribution networks shall be sized for the following targeted maximum head losses at the peak design flow at normal operation conditions (i.e. without fire flow).

Table 3: Head losses in Networks (m/km)

No.	***Pipelines Size (mm)***	***Head losses ranges (m/km)***	***Remarks***
1	100 to 300	1.0 to 3.0	Different ranges are acceptable if hydraulically and economically justified
2	> 300	1.0 to 5.0	Different ranges are acceptable if hydraulically and economically justified.

As the available residual pressure at Transco interface points is generally much higher than 1.25 bars and the distance from the interface points to the end of the distribution networks is relatively short, therefore head losses (m/km) higher than the values shown above may be applied if technically and economically justified and without increasing the required pressure in the network. Also head losses higher than the above values can be applied for the design of short service connections

Suitable value for the friction coefficient for head losses calculation shall be used by the designer according to material, diameter, internal coating, age of pipelines. The designer may use the following values for the C Coefficient for Hazen Williams formula and for the Ks values (pipes roughness value) for Colebrook-White formula for designing the distribution networks including the minor losses in pipelines.

Table 4: Friction coefficient

No.	*Material of pipeline*	*C Value*	*Ks Value (mm)*
1	HDPE	115 to 140	0.11 to 0.07
2	DI	100 to 135	0.15 to 0.08

8.13 Maximum and Minimum Velocities in Water Networks

Ideally the distribution networks shall be designed to achieve minimum pressure criteria in the distribution system in a hydraulically and economically efficient manner. This will be generally achieved at water velocity of 0.4 m to 0.6 m/sec that give head losses of 1.0 to 5.0 m/km in pipelines.

The maximum velocity shall be in a range of 1.0 to 2.0 m/s depending on size of pipeline. However, under certain and justified conditions such as at fire flows velocities up to 3.0 m/s shall be acceptable.

If possible, minimum velocities shall not fall below 0.3 m/s at low demand periods to ensure that the age of the water does not become excessive and that loose deposits in the main are not allowed to settle, only to be lifted into suspension again at peak demand periods.

Table 5: Velocities in Water Networks

No.	*Pipelines Size (mm)*	*Velocity Range (m/s)*	*Optimum Target Velocity (m/s)*
1	100 to 150	0.3 to 1.0	0.4
2	200 to 300	0.4 to 1.5	0.5
3	> 300	0.5 to 2.0	0.6

As the available residual pressure at the interface points is generally much higher than the minimum required pressure of 1.25 bars and the distance from the interface points to the distribution networks is relatively short, therefore the velocity range can be higher than the values shown above if technically and economically justified and without increasing the required pressure in the network.

8.14 Minimum and Maximum Pressure in Networks

Water distribution system shall be sized to ensure that the minimum residual pressures at the customer connection boundary generally not less than 12.5 meters' head (1.25 bar) at all times. The 12.5 m minimum pressure was based on supplying ground tanks at the customer plots. Lower pressures than 12.5 m may be accepted under certain conditions, such as at emergencies and during firefighting. The recommended pressure in water distribution systems is summarized below in Table 6.0: -

Table 6: Recommended Residual Pressure in Distribution Networks

No.	*Description*	*Minimum Pressure (m)*	*Optimum Target Pressure (m)*	*Maximum Pressure (m)*
1	Downstream DMAs feeding points	12.5	15 to 30	40
2	Main pipelines upstream DMAs feeding points	12.5	20 to 40	60

Water distribution network downstream the DMAs feeding points shall be generally designed for a target residual pressure of 15 m to 30 m and maximum pressure less than 40 m.
Main pipelines and water distribution network upstream the DMAs feeding points shall be generally designed for a target residual pressure of 20 m to 40 m and maximum pressure not exceeding 60 m

Transmission and trunk distribution pipelines can be designed for operating pressure exceeding 60 m if higher pressure cannot be avoided through pressure zoning, etc.., in such case DI pipelines without small service connections on the pipelines shall be used.

8.15 Pressure Zoning and Pressure Management

The designer shall target lower pressure less than 40 m in the distribution networks to reduce the burst of pipelines and service connections and to reduce the leakage rates. The following options may be applied to reduce the pressure in the distribution networks.

1- Provide different supply zone such as pumping zones, pressure zone, DMAs etc. with maximum difference of 10 to 15 m between the ground levels inside the pressure zone.

2- Reduce the area of the supply zone and the total length of the water networks inside the supply zone to reduce the total head losses inside the supply zone. Also try to locate the supply point at the side of higher ground level inside the supply zone.

3- Design the pipeline for lower heal losses (m/km).

4- Apply the DMA concept and provide pressure reducing valve at the DMA feeding point, hence lower pressure can be maintained at most of the networks particularly the pipelines with service connections.

5- Provide pressure reducing valve at the interface points, pumping stations, DMAs feeding points, bulk connections and at selected locations in the water networks.

6- Avoid or reduce the number of the small service connections of DN 20 to DN 63 fixed on the main pipelines of high pressure.

7- Reduce the pressure during the low demand hours (night hours) through
i- Control valves at DMAs of varied pressure setting during the day (i.e. to reduce the pressure during night hours).
ii- Provide pump station of different pumping operation scenarios that provide lower pressure at the hours of low demand.

8.16 Material, Pressure Rating and Coating of Pipelines

The water distribution networks shall be generally designed for Allowable Operating Pressure (PFA) of 10 bars. PFA, is defined by the EN 545 and ISO 2531 as “the internal pressure excluding water hammer that a component can safely and continuously withstand under permanent hydraulic service”. The maximum static pressure in network shall not exceed the design pressure at any point.

Higher PFA such as 16 bars, 25 bars, etc.. may be used in special cases defined and approved by AADC such as at long transmission pipelines, etc..

Generally, the pipes of water distribution networks shall be High Density Polyethylene (HDPE) PE100 of pressure rating PN 10 (SDR 17) for the sizes up to 300 mm and DI for the sizes above 300. The pressure rating of the DI pipes and fitting shall be C Class as per TAQA standard specifications.

Table 7: Material and Pressure Rating of Water Distribution Pipelines

No.	Pipelines Size (mm)	Preferred material at lower operating pressure and inside DMAs	Other materials for higher operating pressure and outside DMAs
1	100 to 300	PE100 HDPE SDR 17 (PN10)	PE 100 HDPE SDR 11 (PN16) or DI C Class
2	Above 300	DI C Class	Carbon Steel (CS) only at special cases decided by AADC

Notes on Table 7:-

1- *PE100 HDPE SDR 17 (PN10) shall be used for maximum operating pressures of 4.5 bars.*
2- *PE100 HDPE SDR 11 (PN16) shall be used for maximum operating pressures of 7.0 bars. DI pipelines shall be used for operating pressures higher than 7.0 bars.*
3- *PE 100 HDPE SDR 11 (PN16) or DI C Class shall be used for all bulk connection pipelines of DN 80 and above due to the possible surge pressure. HDPE is the preferred material for the diameters lower than DN 300.*
4- *The pressure class for DI pipeline shall be the preferred pressure class as per table 16 in the ISO 2531 unless higher pressure class is specified by the designer.*
5- *Carbon Steel (CS) pipelines may be used in special and rare cases decided by AADC such as at existing CS pipelines or at high pressures.*

All the flanges in the water distribution networks of PN 16 and below including the stub flanges for HDPE pipelines shall be drilled to PN 16.

The pressure rate of all types of valves, flow meters, strainers, fire hydrants shall be PN 16 as per TAQA standard specifications.

The DI and HDPE pipelines shall be generally connected by stub flanges.

Only Ductile Iron pipes and Ductile Iron/Metal Fittings shall be used inside chambers and exposed pipelines (i.e. pipeline laid above ground). The details of chambers at water distribution networks shall be as per TAQA and AADC Standard Detail Drawings.

For ductile iron pipes suitable internal and external protection methods against corrosion shall be selected to achieve 50 years physical working life for pipelines. The selection of the required protection method shall be based on the available information on soil conditions or based on geotechnical investigations carried out during the construction stage such as the soil resistivity test.

Wrapping tape for corrosion protection shall be applied to all DI and metal pipework fixed on buried HDPE pipelines such as he DI pieces extended outside the chambers, the buried DI isolating valves on HDPE pipelines, etc..

The coating for DI pipes, DI fittings and valves shall be as per TAQA standard specifications. The table below summarize TAQA standard specifications for coating of DI pipes and fittings.

Table 8: Internal and external coating to ductile iron pipes and fittings

No.	*DI Pipes and Fittings*	*Internal and external coating*
1	Internal coating (pipes and socket fittings)	Sulphate resisting cement mortar lining.
2	Internal / External coating (Fittings at chambers and flanged fittings)	Fusion bonded epoxy coating of DFT minimum 300 microns
3	Internal socket ends of pipe	-Zinc rich paint plus a layer of non-toxic bituminous paint OR - Epoxy coating (in case of external coating of polyurethane).
4	External Protection (Pipes)	Metallic zinc coating covered with a bituminous varnish coat OR Solvent free polyurethane.
5	External spigot ends of pipes	Metallic zinc plus layer of non-toxic bituminous paint OR Epoxy coating (in case of external polyurethane coating)
6	Flanges (Flanged branches of buried socket fittings)	Zinc rich paint with bituminous coating OR Epoxy coating for polyurethane coated pipes.
7	External Protection of Socketed Fittings	Zinc rich paint, plus layer of non-toxic bituminous paint OR Solvent free polyurethane min.
8	Additional external protection on site	-Black polyethylene sleeve (250 microns). -Heat shrinkable collars for all the joints (in case of external coating of polyurethane) - Wrapping tape for corrosion protection for pipeline laid at corrosive soil or laid below water tables. Also for DI and metal pipework laid with buried HDPE pipelines.

When TAQA specification or the design guideline specify more than one option for the design criteria (i.e. material or coating for pipes), the designer shall select the optimum option for the considered project and shall justify technically and financially the selected option. Moreover, the selected option shall be defined clearly in the tender document (i.e. in Technical Data Sheets, Bill of Quantities, etc...)

8.17 Size of Pipelines in Water Networks

The sizes used for pipes, fittings and valves in the water networks shall comply with the relevant ISO /EN BS international standards. The recommended sizes to be used in Al Ain water distribution networks are listed below. The minimum size to be used in networks shall be 100 mm for DI and 110 mm for HDPE. HDPE pipelines shall be used for sizes up to DN 355 (300 mm internal dia) and DI shall be used for sizes above 300 mm internal diameters.

Table 9: Size of Pipelines to be used in AADC Water Networks

DI pipes / Valves (mm)	*Equivalent HDPE SDR 17 (PN 10) (mm)*	*Equivalent HDPE SDR 11 (PN 16) (mm)*	*Remarks*
100	110	125	
150	160	180	
200	225	250	
250	280	315	Not a preferred size
300	355	355	DI is preferred for this size
400	450	500	Only DI for new works
500	560	630	Only DI for new works
600	630	710	Only DI for new works
700	-	-	Not a preferred size
800	-	-	
900	-	-	Not a preferred size
1000	-	-	
1100	-	-	Not a preferred size
1200	-	-	

8.18 Water Network Configuration

All water distribution pipelines shall be sized to deliver the Peak Daily Demands (PDD) whilst ensuring the compliance with the requirement of this Design Guidelines and the applied standards and regulations.

The new networks shall be designed considering 24 hours continuous supply. If requested by AADC, the design of networks may be also designed for delivering intermittent and restricted supply.

All system components shall be sized with due consideration to the demand growth projections of the various demand categories and determine 24hour demand pattern for all the categories based on best engineering judgments.

The designer shall apply the engineering judgment to set out and size pipes along routes to serve future requirements, also he shall collect from AADC the planned future water networks that may impact the considered design.

The water distribution network shall be designed preferably as loop/ grid network without branches or dead-ends. In locations where only single or few consumer connections, permanent blow-off arrangement is required.

District Metered Area (DMA), shall be considered in the design of water networks for the purposes of leakage control, demand management and to reduce pressure in network. The adverse impact of the DMAs of reducing the residual pressure in the networks and reducing the security of supply due to the closed DMA boundary valves shall also be considered while planning the DMAs

The water supply system shall be designed to provide two alternate sources to sectors and areas. Risk analysis shall be undertaken to assess the risk of supply interruptions in case of single feed lines or single source. In areas with few customers, single feed line pipeline may be considered.

The fire hydrant location must be in accordance with the Civil Defence requirements. However, each segment of pipe between cross-connections should have a hydrant to facilitate flushing and disinfection of pipeline particularly after repair works. Special attention shall be given to the fire flow requirements.

The layout of the pipeline shall be planned in a way the length of the service connections to all the plots in the project area shall not exceed of 50 m without crossing the asphalt roads. To avoid crossing the roads by the service connections the pipelines may be laid at both sides of the asphalt roads.

The protection of the pipelines and service connections at road crossings and other non-normal laying conditions shall be according to TAQA/AADC standards.

The pipelines shall be laid in the corridors allocated by the concerned authorities for water supply networks.

The designer shall obtain all the required approval during the design stage from the concerned authorities such as pipeline route approval from Town Planning Department (TPD), etc.

The water networks designed and constructed by third party such as Real Estate Developers shall include the followings components: -

- The main pipeline between the tapping point(s) on AADC networks (i.e. water sources) to the project area.
- The water networks within the project area
- The service connections (domestic or bulk connections) if the residential buildings will be constructed simultaneously with the infrastructure. Other arrangement may be agreed with AADC if the residential building to be constructed later such as laying portion of the service connection up to the plot boundary or not providing them with the distribution network

8.19 Hydraulic Analysis of Distribution Networks

The design of the water distribution network shall be carried out by using suitable hydraulic analysis software. The applied criteria, assumptions, input and output of the hydraulic design shall be discussed and presented in the design reports.

Soft copy of the hydraulic analysis shall be submitted with the design report using EPANET software. I.e. the hydraulic analysis shall be converted to EPANET if carried out by using software different than the software of InfoWater Suit that used by AADC. Also, printout of the input and output of hydraulic analysis shall be included in the design reports in colour coded and tabulated format. The drawing shall shows the main hydraulic parameters for the main considered demand scenarios such as the residual pressure, heal losses, diameters of pipelines, head, velocity, etc..

The proposed water networks and the output of the hydraulic analysis shall be submitted to AADC in a format it can be easily converted and incorporated in AADC hydraulic model of Al Ain water supply system. AADC hydraulic model is built in Info-Water Suit software.

The proposed boundaries of the DMAs that cover the new networks, the tapping points to AADC system and the required pressure and flow at the selected tapping points shall be defined at the early design stages in coordination with AADC.

The hydraulic design shall use suitable friction head losses coefficient consistent with the values applied in AADC hydraulic model. The actual inside pipe diameter shall be used in the design and hydraulic analysis of pipelines.

The hydraulic analysis shall consider as a minimum the following design scenario in steady state or extended period simulation for each design option and phase of the proposed scheme: -

- Peak demand without fire
- Peak demand with fire
- Average demand.

The following additional hydraulic analysis scenarios may be considered if requested by AADC: -

- Minimum demand
- Contingency and emergency plans.
- Extended period simulation
- Water Quality modelling

8.20 Pipeline Trenches

8.20.1 Layout and Route of Pipeline

The pipelines shall be laid in the corridor allocated for potable water (if available). The clearance between the pipeline and other services or the crossing of other services shall be as per the TAQA, AADC and TPD standards and requirements. The designer shall obtain the approval of the pipeline route from the TPD and other concerned authorities. A sample of a typical tender drawing for the layout of pipelines showing the minimum details to be presented by the designer is included in AADC Standard Detail Drawings (Drawing No. AADC-AMD-SD 701).

8.20.2 Cover to Pipelines

The depth of cover to water networks laid in normal condition shall not be less than 1000 mm or the dimeter of pipeline if the diameter is greater than 1000 mm. Suitable depth greater than 1000 mm may be applied at road crossings and at other non-normal laying conditions. The pipeline shall be protected by concrete encasement or other arrangements approved by AADC if the minimum cover cannot be achieved.

8.20.3 Width of Pipeline Trench

The trench width shall be as narrow as practical to allow efficient laying, jointing and compaction of the pipeline. Typically the width shall be between pipe OD + 300 mm and pipe OD +600 mm but not less than 600 mm to allow working space.

8.20.4 Protection of Pipelines.

The proposed and existing pipelines may be protected at the following cases :-

- At road crossing and wadi crossings.
- If minimum cover to pipeline cannot achieved
- At soil movements.
- At crossing of other services,

The following protection methods may be applied:-

- Precast concrete slabs above the pipeline. This shall be the main method when the pipeline cross the proposed or existing roads by open cut or the pipeline constructed at same time or before the road. The details of the protection slab shall be as per TAQA specifications and AADC standard drawings.
- Lay the Pipeline through duct. This is an alternative method to the protection slab. The pipes with unrestrained joints such as DI shall be laid with restrained joints inside the duct. Also the service connections of DN 20 to DN 63 shall cross the roads through ducts to facilitate the maintenance and replacement of the connections.
- Pipelines encased in concrete. The details shall be as per AADC standard drawings.
- Laying the pipe at more depth than the minimum specified cover.
- Use imported soil material for bedding and backfilling. If the excavated material not suitable for the bedding or the soil is corrosive to pipeline.
- By using concrete bedding covering the bottom part of the pipeline (in special rare cases approved by AADC) .
- Protect the pipe by gabions and geotextile (in special rare cases approved by AADC) ..

8.20.5 Restraining of Pipelines

The pipelines of unrestrained joints such as the DI with standard joints shall be restrained against the hydraulic thrust at the following locations:-

- Bends
- Tees and dead ends
- Reducers
- Buried valves
- Vertical slope exceeding 1:6
- When connecting restrained pipeline with un-restrained pipeline (i.e. HDPE to DI).

The hydraulic thrust can be encountered by providing one or more of the following measurements:-

1- Thrust / Anchor blocks. TAQA and AADC Standard Details Drawings cover the thrust blocks designed for site test pressure of 9 bars and 16 bars

2- Two line anchor blocks: TAQA and AADC Standard Details Drawings cover the line anchor designed for site test pressure of 9 bars and 16 bars. All the joints between the two anchor lines shall be restrained joints. This method suit the narrow corridors and if there is no sufficient space to construct the thrust block.

3- Restrained joins of adequate length. The restrained length depends on design pressure of pipeline, diameter, depth and friction coefficient between pipeline and soil. The pipeline manufacturer provide table to calculate the required restrained length.

4- Thrust / puddle flanges in concrete chamber. AADC Standard Detail Drawings are designed for 16 bars site test pressure. Other parameters applied to design the chambers are listed in AADC Standard Drawings

5- Combination of two or more of the above. As example 50 % of thrust force encountered by line anchors and 50 % by restrained joints.

8.20.6 Pipeline Profile and Minimum Gradients

The main water pipelines and bulk connections without branches or service connections connected to them for long distance exceeding 1.5 to 2.0 km shall be laid to a minimum gradient slope to facilitate the move of air towards the air valves. Air valves and washout shall be provided along this portion of pipelines. The minimum slope shall be as follows :

- 1:500 for upward flow
- 1:300 or 1:500 + hydraulic gradient for downward flow

AADC Standard details drawings include sample drawing (Drawing No. AADC-AMD-SD 702) showing the minimum details to be presented in a typical pipeline profile drawings prepared for a tender documents. Also the drawing include the criteria and parameters to be applied to design the profile such as the minimum gradients, spacing between air valves, washouts and isolating valves.

8.20.7 Non Destructive Road Crossing (NDRC)

The new pipelines shall cross the existing asphalt roads by Non Destructive Road Crossing (NDRC) methods. The design and the construction of the NDRC shall be carried out as per TAQA specification and AACM requirements by specialized Contractor approved for similar works. The NDRC may be carried out by one of the following Technique :-

- Thrust Boring Technique
- Micro tunneling Technique
- Horizontal drilling techniques

8.20.8 Clearance Between Pipelines and Other Services

The clearance between the potable water pipelines and other services shall be as per TAQA/AADC requirements/ specifications, the requirements of the TPD and other concerned authorities. In absence

of such requirements, the following recommendations of the BS EN 805 may be applied.

1- A minimum 0.4 m horizontal distance between the pipeline and the foundations and other similar underground services

2- A minimum 0.4 m horizontal distance between the pipeline and other pipeline or cable running near or parallel to it. In congestion areas, the distance can be reduced to 0.2 m except if this distance cannot be maintained. In all cases suitable measure shall be taken to avoid direct contact

3- A minimum of 0.2 m when pipeline cross cable. If this cannot be achieved measures shall be taken to avoid direct contact.

4- The possibility of transmission of forces through direct contact shall be eliminated.

5- The following arrangement may taken (as needed) to protect the water pipelines when crossing sewers of other services

- The pipeline shall be laid above the sewer lines
- The pipeline shall be laid through duct
- The pipeline to be surrounded by concrete.

6- If two pipelines are to be laid in one trench, a minimum spacing of 300 mm should be kept between the two pipelines.

The crossing of major services such as gas and oil pipelines and railway tracks shall be carried according to the requirements of these authorities.

8.21 Site Test Pressure for New Pipeline

The site test pressure (STP) for new pipeline shall be carried out as per TAQA and AADC specification. The designer shall specify the site test pressure by filling the test value in Technical Data Sheet in Tender document. If the site test pressure (STP) not specified by the designer it shall be as follows:-

- STP = MDPc + 1.0 bar (if surge calculated)
- TP = the least of MDPa x 1.5 OR MDPA + 5.0 bar (if surge not calculated), while the surge pressure in MDPa shall not be less than 2.0 bar
- Test pressure shall not exceed the PEA of the lowest rated component in the tested water system including the derating of pressure value (if applicable)

Where DMPc is the maximum operating pressure with surge and MDPa the maximum operating pressure without surge.

The test pressure shall be applied at the lowest portion in the tested pipeline and shall consider the derating of the applied pressure such as the derating for HDPE pipelines due to higher temperature or due to the use of certain fittings.

8.22 Rehabilitation and Replacement of Water Networks

Generally, the requirement for Rehabilitation and Replacement of existing Water distribution Networks is assessed and designed internally by AADC. In some cases, AADC may require external designers (Consultants) to prepare tender document for the detailed design prepared by AADC.

8.23 Small /Domestic Service Connections (DN 20 to DN63)

The service connections of DN 20 to DN 63 are considered as small/domestic service connections (DSC). The DSC pipelines shall be generally PE80 MDPE SDR 11 (PN12.5). PE 100 HDPE SDR 11 (PN16) may be used in some cases requested by AADC or as discussed below.

The length of DSC shall not exceed 80 m and preferably less than 30 m from the main pipeline to the customer's boundary and shall be laid with minimum 600 mm cover. The Service connection shall include electronic meter (ultrasonic meter), NRV, lockable valve / service gate valve and strainer all designed according to TAQA/AADC specifications and AADC standard detail drawings.

For the service connections exceeding 80m length and less than 150 m, DN 63 PE100 HDPE SDR11 pipeline laid at 1.0 m minimum depth shall be used even if smaller diameter is needed according to demand. For the service connections exceeding 150 m length, DN 110 PE100 HDPE SDR11 of or DN 100 DI pipeline shall be used even if smaller diameter is needed according to demand. At both cases the connection size shall be reduced at the meter box to diameter required by the demand.

The meter shall be capable of communicating with both Automatic Meter Reading (AMR) options applied by AADC of touch pad and radio frequency (RF) transponder.
Unless otherwise specified and except for the replacement and diversion of water networks, service connections shall not be provided with the new AADC water networks.

Service connection shall be provided with the water networks constructed by third party such as Developers, Al Ain Municipality, etc.. if the infrastructure and buildings are constructed simultaneously.

The size of service connections shall be defined in coordination with AADC during the design stage and shall be confirmed with AADC (i.e. CSD) during the construction stage.
The size of the domestic connection on AADC existing networks is decided by the CSD when the customer applies for the connection. A guide for the recommended sizes for the domestic connections not exceeding 50 m length at continuous supply and sufficient storage capacity at the customer premises is shown below.

Table 10: Guide for sizing Domestic Connections not exceeding 50 m length based on demand.

Nominal size. (External Dia. in mm)	Size in Inches (Approximate Internal Dia)	Demand (IG/Day)
20	½	Up to 1,500
25	¾	1,500 to 3,600

32	1.0	3,600 to 6,000
40	1¼	6,000 to 10,000
50	1½	10,000 to 16,000
63	2.0	According to hydraulic analysis

Notes :

1-The design is based on availability of 24 hours continuous supply and water storage not less than one day demand at the customer premises.

2- The service connection shall be designed by hydraulic analysis if one or more of the above parameters of maximum length, continuous supply and minimum storage at customer premises are not met.

8.24 Bulk Service Connections of DN 80 and Above

The service connections to customers of DN 80 and above are considered as bulk connections (BC). The water demand, design and construction of the bulk connection shall be carried out according to AADC/TAQA applied procedures and standards for bulk connections.

Generally, AADC design bulk connections for the customer after the customer or his representative apply to AADC for the connection. The customer shall construct the bulk connection through a contractor approved by TAQA and under AADC supervision. The customer shall bear all the incurred cost such as the design cost, AADC construction supervision fees and the construction cost.

In some cases, AADC may design and construct the bulk connections under AADC budget and projects. Also, the bulk connection may be designed by a Consultant if the bulk connection fall under water network designed by him, if AADC appointed the Consultant or if AADC requested the customer to appoint a Consultant.

The bulk connection shall include all or part of the following components as defined by AADC in one or more chambers as per TAQA/AADC specifications and standard details drawings: -

- Electromagnetic flow meters suitable for future connection to SCADA.
- Control valves suitable for future connection to SCADA with pressure gauge located downstream the valve. Flow control shall be the prime function of the valve. Control Valve shall operate at lower pressure. Generally the control valves shall be Diaphragm type for sizes of DN 300 and below and shall be Axial type for sizes above DN 300.
- Strainer upstream the flow control valve with two pressure gauges located upstream and downstream the strainer.
- Isolation valves upstream other pipework of the connection
- Non return valve downstream other pipework of the connection.

The following components shall be provided if specifically specified in the design of the bulk connections or requested by AADC.

- Main and backup power source. The main power can be electricity or solar power, the backup power shall be batteries
- Local SCADA instrumentation and SCADA kiosk including flow and pressure transmitters, remote setting of control valve, water quality transmitters (for residual chlorine, PH, turbidity

and temperature), logger for flow and pressure downstream the control valve for a minimum period of 90 days,

- Integration of the local SCADA with AADC CPC station.

The SCADA works at group of existing bulk connections including the integration with AADC CPC station may be provided by AADC from time to time under sperate contracts, therefore the control valve and flowmeter shall be suitable for future upgrade and integration with SCADA systems.

The components to be provided at each Bulk Connection shall be defined by AADC for case by case. The design of Bulk Connection chamber shall allow easy removal of any of the components inside the chamber during the maintenance works.

The size of pipework at the bulk connection chambers may be reduced by one size (if required) to achieve the optimum water velocity through the control valves and the flow meter, however the dimeter shall not be less than 80 mm.

PE100 HDPE SDR 11 or DI (C Class) pipes shall be used for the pipelines of bulk connections of DN 80 and above.

For bulk connections exceeding 1.5 km length, a minimum gradient, isolating valves, air valves and washouts shall be provided similar to the transmission pipelines.

For any bulk connections exceeding 400 m or as requested by AADC, surge analysis shall be carried out and suitable arrangement shall be provided to maintain the surge within the acceptable limits. The arrangement may include reducing the water velocity through flow control valve, reducing the pressure in pipeline through pressure reducing valve(s), fix slow closing valve or floating valve at the customer's tank, use pipeline of higher pressure rating, etc.

The bulk connection shall supply a bulk connection tank located inside the customer plot at location approved by AADC. The tank shall have a minimum capacity of one day average demand and shall be designed as per TAQA specification. The tank shall be fitted with suitable inlet, outlet, drain and overflow pipes. The inlet pipe shall supply the tank from top to prevent the water backflow to AADAC network. An isolating valve and a slow closing float valve shall be fixed on the inlet pipe.

8.25 District Area Meters (DMA)

The design of water distribution networks in Al Ain region shall consider the concept of District Area Meters (DMA). The boundaries of the DMAs and the location of the feeding points shall be defined by AADC or in coordination with AADC.

The following criteria may be applied to define the boundaries of the DMA: -

- Suitable boundary size, inflow rate and number of connections that allow effective operational management of water distribution networks particularly the leakage management. The optimum targeted size of the DMA shall cover 500 to 800 plots. DMAs of bigger boundary may be provided but shall not exceed 1500 plots.

- The differences between the maximum and minimum ground levels inside the DMA boundary shall not exceeding 15 m and preferably less than 10.0 m. Also try to locate the DMA feeding point at the side of higher ground level inside the DMA boundary.
- The total head losses within the DMA at the peak demand without fire shall not exceed 10 m and preferably around 5 m.
- Maintain similarity to the existing DMAs in Al Ain region considering the number of connections and covered areas.
- Use natural and artificial features as boundaries for DMA such as main roads, wadis, boundaries of Municipality districts and Communities,
- At existing networks where possible the DMA shall consist of pipelines of same age and material with minimum change to existing networks.
- Use the boundaries of pressure zones and interface points as boundaries for the DMAs.
- The opening percentage (%) of the control valve at all the demand scenarios including fire flow and future demand shall be within 15 % to 85 %.

The network within the DMA boundary shall be supplied through single feeding point. The feeding point shall include all or part of the following components in one or more chambers as per AADC particular specifications and AADC standard details drawings: -

- Electromagnetic flow suitable for SCADA connection
- Control valves suitable for connection to SCADA with pressure gauge located downstream the valve. The valve shall have both functions of pressure reducing and flow control, pressure reducing shall be the prime function. Valve shall operate at lower pressure. Generally the control valves shall be Diaphragm type for sizes of DN 300 and below and shall be Axial type for sizes above DN 300.
- Strainer upstream the flow control valve with two pressure gauges located upstream and downstream the strainer.
- Two Isolation valves one located upstream the connection and the other located downstream the connection to facilitate removing the control valve and the flowmeter.
- Main and backup power source. The main power can be electricity or solar power, the backup power shall be batteries
- Local SCADA instrumentation and SCADA kiosk including flow and pressure transmitters, remote setting of control valve, logger for flow and pressure for a minimum period of 90 days

The following components shall be provided at selected DMAs if specifically specified in the design of the DMA or requested by AADC.

- Water quality transmitters (for residual chlorine, PH, turbidity and temperature).
- Integration of the SCADA to AADC SCADA (CPS) system including providing all the required accessories and software to integrate the DMA SCADA to AADC CPS) system.

The components to be provided at each DMA shall be defined by AADC. A bypass of the DMA chambers may be provided if requested by AADC.

The size of pipework at the DMA chambers may be reduced by one size or more than the feeding pipeline according to the flow rates. The design of DMA chamber shall allow easy removal of any of the components inside the chamber during the maintenance works.

One or more alternative feeding point to the DMA shall be provided for use during the emergencies. An isolating valve shall be provided at the alternative feeding points; the valves shall be closed during the normal operation.

8.26 Interface Points with Transco

AADC receive water within Al Ain region through many Interface Points with Transco Company (more than 80 existing and planned interface points). The interface points are considered as water sources to AADC system. Transco try to provide the flow and pressure requested by AADC at each interface with the residual chlorine limits specified by the DOE. This reduce the need for pump stations, storage and chlorination facilities in AADC system, but not eliminate the need for these facilities.

Each interface point includes flow meter, control valve, water quality instrumentations, power source, isolating valves, pressure transmitter and connection to Transco SCADA and AADC systems. The isolation valves, flow meters, control valves and water quality instruments are connected to Transco SCADA system and the flow and pressure parameters are monitored in AADC SCADA (CPS) system.

The designer of new networks may propose in coordination with AADC the provision of new interface points on Transco system to supply the network designed by him.
The design of Interface Point shall be carried out according to Transco requirements and the Meter Data Exchange Code of the DOE.

8.27 Isolation Valves at Water Distribution

The isolation valve layouts shall be arranged so as to minimize customer interruptions during the repair work at any section of the main Water Distribution System.
Gate valves shall be used for sizes below 400 mm and Butterfly valves shall be used for sizes of 400 mm and above.

The isolation valves shall be buried valves for sizes up to DN 250, valves in chambers shall be used for sizes above DN 250 and at locations not suitable for buried valves
The details of isolating valve chambers shall be as per TAQA specifications and TAQA/AADC standard drawings.

The layout of isolation valves in the Water Distribution System shall be as per the following guidelines: -

1. To isolate around 10 to 25 plots according to plot size
2. A segment shall require around 4 to 6 valves to be isolated.
3. Located at the branches on ring mains
4. Located around 200 m to 400 m apart from each other in network having high- density customers.

5. Two valves at Tee at selected locations. Not required to provide valves at all tees
6. To keep the supply interruption rates to customers within the limits targeted by AADC.

In a distribution network having wide-spaced customers, the isolating valves shall be located as per the following arrangements:

1- To isolate maximum of 1000 metres of pipe length of distribution main.
2- To isolate maximum of 2000metres of pipe length of secondary main.
3- To isolate maximum of 3000metres of pipe length of primary / ring main.

8.28 Air Release Valve

Air valves are generally not required at networks with service connections because the service connections release the accumulated air in network. Air release valve shall be provided at the trunk pipelines without service connection or branches for length exceeding 1.5 km.

The valves shall be located at peak elevation points and at maximum spacing of 800 m to 1000 m.

Air valve may be provided at networks of intermittent supply to allow fast filling of pipelines during supply hours.
The Air Release Valve shall comply with TAQA specifications and TAQA/AADC standard detail drawings. The sizes specified in TAQA standard drawings are shown in the table below

Table 11: Size of Air Release Valves

Size of Main line (mm)	*Size of Air Valves (mm)*
Up to 300	80
400 to 500	100
600 to 800	150
900 to 1000	200
> 1000	2 Nos. x 200

8.29 Washouts

Washouts may be provided at lowest points to permit repair and flushing of main pipelines particularly the transmission pipelines. Washout may not be provided at small diameter pipelines as small diameter pipelines can be drained through Fire Hydrants by using compressed air and/or pumping.

The spacing between washouts on transmission pipeline shall be between 800 m to 1500 m. The sizes and details at the washout chambers shall be as per TAQA specifications and TAQA/AADC standard detail drawings. The sizes specified in TAQA/AADC standard drawings are shown in the table below.

Table 12: Size of Drain lines at Washouts

Size of Main line (mm)	*Size of Drain line (mm)*
150 to 200	80
250 to 300	100
400 to 500	150
600 to 1000	200

> 1000	250

8.30 Fire Hydrants

The aboveground fire hydrant shall be of the breakable pillar type with two nozzles of 2 ½ inches and one nozzle of 4 inches outlet as per TAQA specification and accordance to the requirements and specifications of the Directorate of Civil Defence.

The underground fire hydrant shall be of screw down type of DN 80 size with screwed 2½ inches round threaded outlet conforming to TAQA specification. Most of the installed Fire Hydrants in Al Ain are underground type; however, the Civil Defence has changed their requirements to use only Pillar type hydrants in water networks. Therefore (unless otherwise specified) only Pillar type shall be specified.

The number and location of external fire hydrants is dependent on-site planning, building design and the fire risk associated with the development land use. Hydrants are to be positioned along Civil Defence access routes. Hydrants shall be located at 150 m spacing.

Hydrants should be clearly visible and marked with approved signage. The details of the fire hydrants shall be as per AADC standard detail drawings.

8.31 Fire Fighting Requirements

The design criteria of fire fighting in water distribution systems in all new developments shall be in accordance to the requirements of the "Water Distribution Code" published by the DOE and the requirements of the Civil Defence. The Table below summarize the Minimum Fire Fighting Flow requirements stated in the Water Distribution Code (Version 4.0, November 2018). The designer shall refer to Appendix D in the WDC for complete details of the Fire Fighting requirements

Table 13: Minimum Firefighting Flow Requirements (Water Distribution Code)

Hazard Type	No. of Hydrants	Total Flow (l/min)	Min. Residual Pressure (Bar)	Hydrant Spacing (m)	Flow Duration (minutes)
Low Hazard-Residential	1	1900	1.25	100 - 150	30
Medium Hazard-Commercial	2	3800	1.25	75 - 100	60

8.32 Soil Resistivity Survey for Metal Pipelines

Soil resistivity survey may be carried out to determine the corrosivity of the soil along the route of metal pipeline (DI, Steel) to select suitable external coating for the buried pipes and fittings.

The variations in resistivity along the pipeline routes may be defined within the following bands.

000.0	- 1000	ohm-cm	Highly Aggressive
1000 -	3000	ohm-cm	Aggressive

3000 - 10000	ohm-cm	Mildly Aggressive
> 10000	ohm-cm	Non-Aggressive

The Soil Resistivity Survey shall be carried out according to AADC particular specifications.

8.33 Storage at Customer's Premises

AADC role inside the customer's premises is limited to approving the size and location of the customer's tanks, AADC approval is usually provided when customer apply for the service/bulk connections.

The total storage at customer's premises shall be according to the criteria stated by the DOE (Guide to the Water Supply Regulations, 2017). This criterion is summarized as follows: -

1. The total storage capacity (ground tanks and roof tanks or cistern) shall be estimated as follows: -
   i- Minimum Capacity = 1 x daily consumption + firefighting reserve to be held completely in the ground tank
   ii- Maximum Capacity = 2 x daily consumption + firefighting reserve to be held completely in the ground tank

2. The roof tank should always be sized to hold sufficient water to supply between 12 and 24 hours of the Premises' total daily consumption, irrespective of the provision of ground storage tanks. In situations where no ground tanks are allowed for, the actual roof storage capacity shall be sized for 24 hours.

3. For high-consumption customers (such as hotels and hospitals) provided with ground storage tanks only, the complete water capacity may be held in the ground storage tank if the Distribution Company has approved the boosting arrangements.

8.34 Pumping Stations

8.34.1 Design of Pump Stations

The pump stations are not covered in detail in this design guidelines because new pump stations may be rarely required in AADC system because the required pressure for AADC existing and future networks are usually provided or requested at the interface points with Transco.
Therefore, small portion of the distributed water in Al Ain region is supplied through few pump stations belong to AADC. These arrangements reduce considerably the need for new pump station in AADC system. Hence the designer of water distribution networks shall utilize the available pressure at the interface points and at AADC networks and shall try to avoid proposing new pump stations.

Generally, the design works at AADC pump station may be limited to rehabilitation works, upgrading/ improving the capacity and chlorination systems, etc.

The design of pumping system shall be according to TAQA standard specifications.

8.34.2 Water Pumps Configuration

The Configuration of Water Pumps shall be as recommended by the DOE in the WSC as follows:

a. A pump-group(s) in a pumping station shall have a combination of duty and standby pumps.
b. Where more than one pump-group is installed in a pumping station, each pump-group shall have its own standby pump.
c. The level of security shall be between 30% to 40% standby capacity provided at the pumping station. This is to maintain security of water supply in case duty pump(s) failure (depending on the frequency of the failure) or in planned maintenance situations.
d. The number of standby pumps required to be provided shall be in accordance with the table shown below. However increased number of standby pumps must be justified by undertaken risk analysis to individual parts of the system to ascertain the optimum number of standby pumps. Increased numbers are also needed to be considered in the case where no alternative supplies are available in the event of frequent failures or to areas classified as critical

Table 14: Standby Pumps Provision

Number of Duty Pumps	***Number of Standby Pumps (standard) (33%)***	***Number of Standby Pumps (Increased) (43%) ****
1	1	1
2	1	1
3	1	2
4	1	2
5	2	2
6	2	3
7	3	3
8	3	3

Source: Water Distribution Code

8.34.3 Pump Sizing

All Pumps including fixed speed and variable speed pumps must be capable of supplying output required (pressure and flows) to meet the level of service set by the local supply requirements and also considering the future requirements. The pumps should be able to:

i) Deliver the maximum flows with the pressures required
ii) The duty pump(s) must have adequate capacity to satisfy the flow and pressure requirements of the water distribution system with view to pressure management.
iii) The standby pump(s) shall have the same capacity of the maximum size duty pump(s) to meet pumping rate, in case any of the duty pump/s is out of service.

Standby generators (either fixed or mobile) shall be provided for Pump Stations where no alternative power supply is available (for example, through dual feeds) and where a risk assessment, as per the risk analysis has shown that service to customers is compromised.

8.34.4 Operation Scenarios of Distribution Pumps

The designer shall define the required combinations of flows and pressures from the pump station at different demand scenarios that gives optimized operation cost. Typically a minimum three demand scenarios may be considered for the design of distribution pumps as follows:-

- Peak hour demand and associated pumping head
- Average demand and associated pumping head
- Minimum hour demand and associated pumping head

The associated pumping head for each demand scenario shall be the head that provide optimum target pressure in all parts of supplied networks at higher efficiency points on the pump's curves.

The above three scenarios may be achieved at higher efficiency of pumps by using two or more sets of pumps of different capacities fitted with variable speed drives.

During the construction stage, the contractor shall select pumps fulfill the above criteria and shall submit for ADAC approval the needed documents confirming proper selection of pumps.

If the pump station supply small network Jockey pumps (i.e. pumps of small flow rates) may be provided to maintain the minimum pressure in the networks during the minimum demand period.

8.35 Water Reservoir

8.35.1 Design of Water Reservoirs

Most of the required storage capacity is provided upstream AADC system such as at Transco system. This arrangement in combination with the DOE requirements of customers tanks of 1 to 2-day demand capacity at each premises reduce considerably the need for new water reservoirs in AADC system, but not eliminate the need for such facility.

As new storage facilities may be rarely required in AADC system, therefore, the water storage is not covered in detail in this design guideline.

Most of the design works at AADC storage facilities is limited to rehabilitation works, etc.
The design of storage facilities system shall be carried out according to TAQA standard specifications.

8.35.2 Sizing of Water Reservoirs

Service reservoirs shall be designed to serve mainly water storage for operational purposes and to balance downstream diurnal variations in demand with relatively constant rates of inflow mainly during high demand.

- In addition to provide contingency storage in the event of a failure in transmission system or during maintenance outages. It also provides damping effect so that small fluctuations are not reflected in the Water Distribution System.
- In considering the provision of Water Distribution System storage the following shall be taken into consideration:

(a) Volume should be calculated based on Average Daily Demand (ADD) including fire reserve and the volume of storage so calculated shall be usable and exclusive of any unusable top or bottom water storage.

(b) All water storage facilities should have a minimum of two tanks, or one storage tank with minimum of two section or more that can be isolated, at each location;

(c) The volume of storage tanks at Distribution pumping station acting as forwarding station to other pump stations and to the network should be based on the Average Daily Demand (ADD) including fire reserve in addition to 10% of the design output to the pump station.

(d) All reservoirs should have interconnecting and bypass arrangements.

8.36 Water Quality in Distribution Networks

AADC receive water at Transco interface points of water quality and residual chlorine rates within the limits defined by the DOE. This arrangement reduces the need for new chlorination facilities in AADC system, but not eliminate the need for such facility. Therefore, the chlorination facilities are not covered in details in this design guidelines.

Most of the design works for chlorination facilities at AADC system may be limited to chlorine re-dosing, rehabilitation, upgrading or replacing the existing chlorination systems.

The design of the chlorination facilities shall be carried out according to TAQA standard specifications.

The designer of the water distribution networks shall consider the water quality by the followings: -

i- Avoid the water stagnation by maintaining reasonable velocities and eliminating the dead ends
ii- Provide water quality sampling points at selected points in the new distribution networks such as at the DMA feeding points, bulk meters, etc.
iii- Provide water quality instrumentations and sensors at selected points in the new distribution networks such as at the DMA feeding points.
iv- Perform water quality modelling for the new networks if requested by AADC.
v- Provide washout or locate fire hydrants at the areas where water may be stagnated to allow flushing out stagnated water.

8.37 Protection and Diversion of Existing Pipelines

8.37.1 Protection of Proposed and Existing Pipelines.

Generally, all the new pipelines shall cross the existing asphalt roads by Non-Destructive Road Crossing (NDRC) methods. The design of the NDRC shall be carried out by the contractor and shall be approved by the concerned authorities including AADC.

The existing pipeline shall be protected by concrete slab if the new road would pass above the existing pipeline. The pipeline shall pass through duct or shall be protected by concrete slab if the road and pipelines would be constructed at same time (i.e. constructed under same project).

8.37.2 Diversion of Existing Pipelines.

The existing pipelines shall be diverted by third parties and at their own cost at the following cases: -

i- The existing pipeline would pass longitudinally under the proposed new road or under the

embankment of the proposed new road.

ii- The pipeline become within private plot or need to be diverted due to the re-planning of the area. Also, if the pipeline will become very deep or shallow due to the third party works such as due to new roads crossing the pipelines,

iii- The diversion was requested by any party other than AADC and approved by AADC.

The other diversion cases that not fall under the above categories would be usually designed by AADC and constructed by a contractor appointed by AADC.

The party that requested or benefited from the diversion shall design the diversion which shall be of the same size of the existing pipeline and shall submit the design for AADC approval. Also, he shall obtain the required approval from other concerned authorities such as TPD. The diversion shall be constructed by the requesting party and at his own cost through a contractor registered with TAQA for such works. All the construction works shall be carried out under AADC supervision.

All the domestic /bulk connections that affected by the diversion shall be relocated on the new pipeline without any cost to AADC.

8.38 Ducts for Future Water Pipelines.

Ducts for future water pipelines shall be provided under the new asphalt roads in Al Ain region. The AACM/DOT or their representatives shall apply to AADC during the design stage of the roads requesting AADC to define the size and location of future ducts under the proposed roads.

AACM/DOT or their representatives shall design the future ducts according to the locations and sizes issued by AADC. The AACM/DOT or their representatives shall apply again to AADC during the construction stage requesting the final location and sizes of future ducts.

As Built drawing for the constructed ducts shall be submitted to AADC.

9. ANNEXURES

9.1 LIST OF DOCUMENTED INFORMATION (INTERNAL)

DOCUMENTED INFORMATION	DOCUMENT ID
HSE Risk Management (AMD)	RR.HSEMS.01
Environmental Management Procedure	CP.HSEMS.15
HSE Legal Compliance	CP.HSEMS.03

9.2 LIST OF STANDARDS

STANDARD CODE	TITLE
ISO 9001	Quality Management Systems
ISO 14001	Environmental Management Systems
ISO 45001	Occupational Health and Safety Management Systems
ISO 55001	Asset Management Systems

10. REFERENCES

- Water Distribution Code (WDC), version 4, July 2018, published by the DOE.
- Guide to the Water Supply Regulations, version 3, 2017, published by the DOE
- TAQA Standard Specifications for Water Works.