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GAS INTERCONNECTOR GREECE-BULGARIA

Design Basis Memorandum

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LIST OF REVISIONS

REVISION	Date	Description
00a	07.06.2017	Draft version
00b	07.07.2017	Draft version
01	19.09.2017	Comments Incorporated

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The current document was developed on the basis of document 10760-PHL-EN-00-001 Rev 2 - FEED & EIA for Natural Gas Interconnector Greece – Bulgaria (IGB) Project - by Consortium "Penspen Limited – C&M Engineering S.A.

Introduction

1.1 General

ICGB AD is a company set up and existing under Bulgarian law and hereafter known as the CONTRACTING ENTITY. The CONTRACTING ENTITY awarded the consortium of Penspen Ltd and C&M Engineering SA, known hereafter as the CONTRACTOR with the Front End Engineering Design (FEED) and Environmental Impact Assessment (EIA) and GASTEC BG AD with the Engineering of Technical Design in Bulgaria for a proposed 32" diameter high pressure gas pipeline, called the "Gas Interconnector Greece – Bulgaria" (IGB).

The IGB buried pipeline will transport natural gas over the border between Greece and Bulgaria, connecting at Komotini with DESFA system and TAP pipeline (as an option) in Greece with an existing gas pipeline near the Bulgarian town of Stara Zagora. The proposed pipeline will measure a total distance of approximately 182.54 km, (31.63 km in Greece and 150.91 km in Bulgaria).

The design of this bi-directional pipeline system shall be in accordance with the internationally recognised codes of practice: EN1594, EN ISO 3183:2012 and ASME B31.8, and also in conjunction with National Regulations, for the safe transportation of 3 bNcmy of gas initially, with the provision for the future expansion up to a maximum technical capacity of 5 bNcmy. The project also includes the construction of the associated Above Ground Installations (AGIs).

1.2 Purpose of Document

The purpose of this document is to provide a basis for all aspects of design for the Interconnector Greece Bulgaria Pipeline Project in order to realise a gas pipeline that provides a high level of reliability, availability and safety. The basis will promote simplicity, robustness and will enable design for minimal capital and lifecycle costs.

The basis will outline requirements for the design of automatic remote operation and performance monitoring, with the provision for manual intervention and operation when required. A consistent design approach with common functionality for the whole pipeline system will be outlined. Due to differences between Greek and Bulgarian national legislation there will be some unavoidable design differences for the pipeline in the two territories.

2. Definitions and Abbreviations

2.1 Definitions

CONTRACTING ENTITY: ICGB AD;

CONTRACTOR: Engineering of FEED – Consortium formed by C&M Engineering SA and Penspen Ltd.
Engineering of Technical Design in Bulgaria – GASTEC BG AD

SUPPLIER : Supplier of Equipment or Materials

Throughout this document the following terminology is used:

"must" : signifies a legal or statutory requirement

"shall" : signifies a requirement made mandatory by this specification

"may" : signifies a feature, which is discretionary in the context in which it is applied

"will" : signifies a feature which the CONTRACTOR / SUPPLIERS may assume to be already present.

2.2 Abbreviations

AC	Alternating Current
AFD	Approved for Design
AGI	Above Ground Installation
AGRS	Automated Gas Regulating Station
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATEX	Atmosphere Explosive

BMS	Building Management System
bNcmy	Billion Normal Cubic Meters per Year
CAPEX	Capital Expenditure
CCTV	Closed Circuit Television
CP	Cathodic Protection
DBM	Design Basis Memorandum
EIA	Environmental Impact Assessment
ESD	Emergency Shut Down
Ex 'd'	Explosion Proof (flameproof)
Ex 'p'	Explosion Proof (pressurised)
EExi	Explosion Proof (intrinsically safe)
F & G	Fire and Gas
FEED	Front End Engineering Design
FOC	Fibre Optic Cable
GMS	Gas Metering Station
HDD	Horizontal Directional Drilling
HDPE	High Density Polyethylene
HSAW	Helical Seam Submerged Arc Welded
HV	High Voltage

HVAC	Heating, Ventilation and Air Conditioning
HYSYS	Proprietary Gas Modelling System
IEC	International Electro-technical Commission
IR	Infra-Red
IO	Input Output
ISO	International Standards Organisation
LSAW	Longitudinal Seam Submerged Arc Welded
MIP	Maximum Incidental Pressure
MOP	Maximum Operating Pressure
MNcmd	Million Normal Cubic Meters per Year
NMS	Network Management System
OPEX	Operational Expenditure
PCS	Process Control System
PLDS	Pipeline Leak Detection System
PVC	Polyvinyl Chloride
RCC	Remote Control and Communication
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
SCC	Sub Control Centre

SI	International System of Units
UCP	Unit Control Panel
UPS	Uninterruptible Power Supply
XLPE	Cross Linked Polyethylene

3. Applicable Codes and Standards

The pipeline system and associated facilities shall comply with national regulations and international codes, norms and legislation applicable for the design, gaining of permits, licenses, authorisations and operation of pipelines and associated facilities in Bulgaria and Greece.

The applicable project norms and legislation are provided in project document List of Applicable Norms and Legislation, document number 10760-LST-EN-00-001 and List of Applicable standards applied in the relevant parts of the Technical design.

4. Design Data

4.1 Basic Design Data

4.1.1 Design Life

The design life of the major items shall be a minimum of 50 (fifty) years. Major items include the pipeline and cathodic protection system, Automated Gas Regulating Stations (AGRS), Gas Metering Stations (GMS), pig launcher/receiver facilities and block valve stations. Some components within the above major items may have a design life less than 50 years. In these cases the reduced design life and component replacement will need to be incorporated into the eventual pipeline asset management system.

4.1.2 Units

The units used for all calculations and in all drawings and documentation are listed in Appendix A.

4.1.3 Battery Limits

The battery limits for the IGB pipeline System are as follows:

- Tie-in to upstream transmission system at Komotini (National Gas Transmission System),Option the tie-in to TAP, Greece
- Weld cap for connection to downstream distribution system or consumer at Kardjali Off-take (Citygas AD), Bulgaria
- Tie-in to downstream transmission system at Dimitrovgrad Off-take (Bulgartransgaz), Bulgaria
- Tie-in to downstream transmission system at Stara Zagora (Bulgartransgaz), Bulgaria

4.1.4 Gas Base Conditions

All gas volumetric flows in this document are referred to the following Normal Conditions:

Normal Pressure:	101.325 kPa
Normal Temperature:	0°C

The overall control scheme shall also cover the monitoring of gas quality within the pipeline system with gas chromatographs located at all fiscal metering stations.

4.2 Design, Operating and Incidental Pressures

4.2.1 Pipeline Design Pressure, MOP and MIP

Pipeline Design Pressure:	80 barg
Pipeline MOP:	75 barg
Pipeline MIP:	82.5

The pipeline MIP has been set at 110% MOP.

4.2.2 Above Ground Installation Design Pressure, MOP and MIP

AGI Piping Design Pressure:	80 barg
AGI Process Equipment Design Pressure	82.5 barg
AGI MOP:	75 barg
AGI MIP:	86.25 barg

The MIP for AGIs has been set at 115% MOP in accordance with the EN 1594 Section 6.3. The station MIP is set slightly higher than the pipeline MIP to facilitate the setting of vessel pressure relief valves (for the protection of isolated AGI piping spools and vessels in the event of a station fire).

4.3 Supply and Delivery Pressures

4.3.1 Supply and Delivery Pressures – Flow from Greece to Bulgaria

The following supply and delivery pressures are applicable for pipeline flows in the direction from Greece to Bulgaria only:

Greece to Bulgaria operation		
Free Flow Condition – without compression at Kipi border station	Supply pressure from Komotini	45 barg
	Delivery pressure to Stara Zagora	42 barg

Free Flow Condition – with compression at Kipi border station	Supply pressure from Komotini	57 barg
	Delivery pressure to Stara Zagora	42 barg
With compression on IGB Pipeline and compression at Kipi Border Station	Supply pressure from Komotini	57 barg
	Delivery pressure to Stara Zagora	52 barg*

*For this case slight pressure reduction may be required at Stara Zagora GMS so that the delivery pressure is compatible with the downstream Bulgartransgaz system (which has a design pressure of 54 barg).

4.3.2 Supply and Delivery Pressures – Flow from Bulgaria to Greece

The following supply and delivery pressures are applicable for pipeline flows in the direction of Bulgaria to Greece only:

Bulgaria to Greece operation		
Free Flow Condition	Supply pressure from Stara Zagora	40.4 barg
	Delivery pressure to Komotini	36.23 barg
With Compression on IGB pipeline	Supply pressure from Stara Zagora	40.4 barg
	Delivery pressure to Komotini	57 barg

4.4 Gas Design and Operating Temperatures

Maximum gas design temperature:	60°C
Maximum gas operating temperature:	50°C

Gas temperatures between a future gas compressor and gas cooler could be higher. This shall require separate analysis during detailed design for a future compressor station.

4.5 Pipeline and AGI Piping Design Temperatures

4.5.1 Pipeline Design Temperatures

Minimum design temperature (underground)	0°C
Minimum design temperature (above ground)	-29°C
Maximum design temperature (underground)	40°C
Maximum design temperature (above ground)	80°C
Minimum allowable low temperature excursion for unusual operations (e.g. blowdowns) for the entire length of the pipeline	-14°C
Minimum design temperature for station blowdown vent piping (downstream of the last isolation / blowdown valves)	-48°C

4.5.2 Above Ground Installation Piping Design Temperatures

Minimum design temperature - underground	-29°C
Minimum design temperature - above ground	-29°C
Maximum design temperature - underground	40°C
Maximum design temperature - above ground	80°C
Maximum design temperature - above ground, under shelter	60°C

Maximum design temperature - above ground, in building	60°C
Minimum design temperature for station blowdown vent piping (downstream of the last isolation / blowdown valves)"	-48°C

4.6 Gas Flow Distribution from the Supply Facilities

The design will be based on the following steady state flows:

System gas capacity	Gas Capacity (bNcmy)
Initial	3
Future	5

The following gas flow distribution for Greece to Bulgaria operations has been assumed for the IGB pipeline project:

Flow Gas Distribution	Gas Flowrate (bNcmy)	
System Capacity	Initial	Future
Kardjali	0.08	0.08
Dimitrovgrad	0.66	1.09
Stara Zagora	2.34	3.83
Total	3	5

Notes:
1. Flows to Kardjali and Dimitrovgrad as per ICGB letter dated 13th September 2011.
2. Flow to Stara Zagora to be confirmed by the Client.
3. Full flow (3BNCMY and 5 BNCMY) without offtakes shall also be possible.

For the reverse flow mode, it has been assumed that the flow distribution to the intermediate consumption centres remains the same,

and that the flow to Komotini is equal to the gas flowrate to Stara Zagora.

A load factor of 0.9 has been assumed and applied to the yearly flowrates. Hence, applying this load factor, the daily gas flowrates are:

Flow Gas Distribution	Gas Flowrate (MNcmd)	
System Capacity	Initial	Future
Kardjali	0.24	0.24
Dimitrovgrad	2.01	3.32
Stara Zagora	7.12	11.66
Total	9.13	15.22

Notes:
1. Load factor to be confirmed by the Client.
2. Flows to Kardjali and Dimitrovgrad as per ICGB letter dated 13th September 2011.
3. Flows to Stara Zagora to be confirmed by the Client.

4.7 Gas Specification and Quality

The IGB Pipeline system shall be able to handle and efficiently transfer gas with composition ranges in accordance with Greek legislation. The gas composition and water content to be used for the IGB FEED, as confirmed by the response to Technical Query reference number 10760-PM-TQ-002, is given in the table below.

	Concentration (mol%)		
Component	**Greek Gas**	**Greek Code Gas**	**Bulgarian Gas**
Methane (CH_4)	94.08	78.50	97.8396
Ethane (C_2H_6)	2.80	7.57	0.8537
Propane (C_3H_8)	0.70	2.52	0.2792
i-Butane (iC_4H_{10})			0.0459
n-Butane (n C_4H_{10})	0.28 Note 2	1.58 Note 2	0.0461
i-Pentane (iC_5H_{12})			0.0090
n-Pentane (n C_5H_{12})	0.09 Note 3	0.63 Note 3	0.0065
Hexane (C_6H_{14})			0.0059
Nitrogen (N_2)	1.81	6.0	0.6198
Carbon Dioxide (CO_2)	0.22	3.0	0.2943
Oxygen (O_2)	0.02	0.2	0.00
Total	100.0	100.0	100.0
Hydrocarbon Dew Point	-56.7°C at 55 barg	-3.9°C at 55 barg	-76.8°C at 55 barg
Lower Heating Value	36.7 MJ/Nm^3	38.2 MJ/Nm^3	36.1 MJ/Nm^3
Higher Heating Value	40.7 MJ/Nm^3	42.2 MJ/Nm^3	40.1 MJ/Nm^3

Notes
1. Gas is considered dry, i.e. water dew point will be confirmed by the Client at the stage - commercial contracts and specifications
2. The split of butane between n-Butane and i-Butane is not known. The C_4 content is assumed to be n-Butane (Greek gas).
3. For simulation purposes, the C_5H_{12}+ component (Greek gas) will be simulated as n-Pentane.

4.8 Pressure Losses

The following facility pressure losses will be applied during the development of the pipeline design due to good engineering practice:

4.8.1

Initial and Future Flows (3 bNcmy and 5 bNcmy)	GMS	0.0barg
All Flows	Block Valve Stations	0.0 barg

Note: Facility pressure drop is 0 bar due to the close values of the starting and ending pressure in hydraulic simulation. Since at low speeds the pressure drop in the AGI tends to zero is passed a value of zero.

4.8.2

Initial and Future Flows (3 bNcmy and 5 bNcmy)	GMS	0.5barg
All Flows	Block Valve Stations	0.0 barg

4.9 Maximum Flow Velocities

In accordance with good engineering practice to maintain acceptable pressure drops, erosion rates and noise levels, the maximum gas velocity in the Pipeline and AGI piping will not exceed 15 m/s during normal operation and criteria regarding ρv^2 to be less than 10000Pa should also be met.

4.10 Environmental Data

Air temperature	Max. summer in shade:	+44 °C
	Mean summer:	+25°C
	Min. winter:	-24°C
	Mean winter:	+5°C

Max. material surface temperature (summer in sun):	80°C
Design air temperature for winterising:	-21°C
Design air temperature for fire water winterising:	-24°C
Design temperature for hot service:	-21°C

Relative air humidity	Minimum:	41%
	Maximum:	85%
	Mean	67%

Precipitation	Max. recorded rainfall in 1 h Max. recorded rainfall in 24 h	36 mm 232 mm
Design snow load:	Acc. to EN 1991-1-3	
Max. soil temperature at 1.5 m depth:		+22°C
Min. soil temperature at 1.5 m depth:		+6°C
Design wind load:	Acc. to EN 1991-1-4	

The above environmental data is subject to agreement with ICGB AD.

4.11 Seismic Data

Sections of the pipeline route will be constructed in areas prone to seismic activity/earthquakes. The facilities and equipment, including the pipeline and other associated above ground installations, shall be designed to survive design seismic events.

Suitable pipeline design measures shall be implemented at seismic zones/fault locations to mitigate the impact of any seismic activity. Earthquake resistant design methods shall be applied in the design of buildings and structures at all AGIs in accordance with the detailed requirements of the seismic code. These design mitigation measures aim to reduce the effects of seismic activity on the pipeline and maintain maximum availability.

Seismic loads of pipeline:	According to seismic hazard assessment
Seismic Design Code	EN 1998 / Ordinance No Rd-02-20-2 of 27th of January 2012 for the Design of buildings and structures in earthquake areas (Bulgaria), and EAK 2000 (Greece), see section 8.11.5
Seismic risk zone in Greece	Zone 1
Design ground peak acceleration for Building/Structures in Greece:	0.16g

Seismic risk zone in Bulgaria	VII or VIII or XI (depending on location)
Design ground peak acceleration for Building/Structures in Bulgaria:	0.10 or 0.15g or 0.27g (depending on location)
Importance Category for Building/Structures	Seismic level IX according Ordinance No Rd-02-20-2 of 27th of January 2012 for the Design of buildings and structures in earthquake areas or Category Σ4 to EAK 2000, see section 8.11.5.

5. Pipeline Design

5.1 General

The pipeline, block valves, AGIs and associated piping shall be designed in accordance with Bulgarian Ordinances, DESFA Standards and the latest applicable codes and standards listed in project document List of Applicable Norms and Legislation: 10760-LST-EN-00-001 and List of Applicable standards applied in the relevant parts of the Technical design. Note that the Bulgarian Ordinances will apply in Bulgaria only, and the DESFA Standards will apply in Greece only.

The principal design standard to be applied to the pipeline, in accordance with EU Regulations, shall be the latest edition of EN 1594 and EN ISO 3183:2012 . This standard recognises that it is not a design handbook or code of practice and that where insufficient guidance is given it shall be supplemented by national or company standards.

EN 1594 does not give full consideration of design factors regarding the routing of pipelines in areas of increased population or at crossings, nor does it deal with decompression cooling (e.g. during pipeline venting). In these cases the requirements of Bulgarian Ordinances, Greek regulations, ASME B31.8 and industry norms shall be applied.

5.2 Alternative Route Options

Within Bulgarian territory, two alternative pipeline routes, called the Eastern and Western Routing Corridors, were investigated.

The routes begin near the Makaza Pass (on the Greek border in the south of the country). They terminate at a convergence point adjacent to an existing pipeline, just north of the town of Haskovo. From this convergence point the IGB Pipeline route continues north, generally running parallel to the existing pipeline, and terminates at the proposed GMS / PS2 facility and the connection to the existing gas network, near Stara Zagora.

The routes have been established and professional judgement used to assess and compare the two routing corridor options in terms of their environmental, social and economic impacts to offer a preferred route for approval.
The chosen route meets all above mentioned requirements and criteria and Tehnical design is development on it.

5.3 Reference Coordinate System

Three coordinate reference systems will be used for the routing of the pipeline. The local system to be used in Bulgarian territory will be the System 1970 (Local B BG70). The local system to be used in Greece will

be HAGS 87. To aid with continuity the WGS 84 (geoid) UTM35N system will be used across the entire pipeline.

5.4 Pipeline diameter and length

The pipeline will have a nominal Outside Diameter (OD) of 32 inches (813 mm). The overall horizontal length of the pipeline is 182.54 km, (31.63 km in Greece and 150.91 km in Bulgaria).

5.5 Wall Thickness

Pipeline wall thickness have been calculated as part of the FEED study in accordance with EN 1594. No corrosion allowance will be added to pipeline wall thicknesses.

5.6 Location Classification and Design Factors

The pipeline Location Classes and Design Factors (DF) shall be assigned in accordance with Bulgarian ordinances and Greek regulations, supplemented where appropriate by the guidance given in ASME B31.8. Design factors shall in no case be higher than the maximum values allowed by EN 1594.

A four tier location classification system will be used (location classes 1, 2, 3 and 4). For the determination of location classes all buildings intended for human occupation, located within a 0.4 km wide zone centred on the pipeline, shall be considered. For any 1.6 km length of pipeline the number of features and properties within the zone shall be used as a basis for assigning the location class.

When a highly localised cluster of buildings intended for human occupancy indicates that a 1.6 km length of pipeline should be assigned a location class of 2 or 3, the location class 2 or 3 may be terminated 200 m from the nearest building in the cluster.

The following sections detail specific Bulgarian and Greek location classification and design factor requirements. Due to slight differences between Bulgarian and Greek requirements, it has been necessary to separate the two.

Refer to the tables in Appendix B for a summary of the pipeline design factors to be used for the Bulgarian and Greek territories, including localised design factors applicable at various pipeline crossings (road, railway, river, seismic fault, HDD crossings etc.).

5.6.1 Bulgarian Location Classification Requirements

The following location classification system is based on the requirements detailed in the "Bulgarian Ordinance as per art. 200(1) of the Energetics Act", Article 13 and the Bulgarian "Ordinance on the

structure and safe operation of transmission and distribution pipelines and facilities, installations and equipment for gas", Article 13.

For the 0.4 km wide, 1.6 km long zones:

Class 1: 10 or less buildings intended for human occupancy

Class 2: more than 10, but less than 46 buildings intended for human occupancy

Class 3: 45 or more buildings intended for human occupancy, or any building or area within 100 m of the pipeline where regular concentrated gatherings of people may occur. A concentrated gathering is defined as a group of 20 or more people, gathering for at least 5 days a week for at least 10 weeks a year (the weeks do not need to be consecutive). This requirement may apply to religious buildings, schools, recreation areas, theatres etc.

Class 4: Areas with multi-storey buildings (4 or more levels) intended for human occupancy.

For multiple dwelling buildings (e.g. blocks of flats or apartments), each flat should be counted as a separate building intended for human occupancy.

5.6.2 Bulgarian Design Factor Requirements

The following design factors are based on the requirements detailed in the "Bulgarian Ordinance as per art. 200(1) of the Energetics Act", Article 14 and the Bulgarian "Ordinance on the structure and safe operation of transmission and distribution pipelines and facilities, installations and equipment for gas", Article 14.

Bulgarian Pipeline Design Factor Requirements

Location Class	Design Factor
1	0.72
2	0.6
3	0.5
4	0.4

The following additional design factor requirements will apply at specific locations / crossings.

A design factor of 0.6 or less will apply in location class 1 areas:

- Through swamps, rivers, streams
- When crossing railway lines

- When crossing highways (motorways) and national roads, class I, II and III
- When crossing high voltage overhead powerlines (> 110kV)
- For the buried pipeline and facilities located within 10m upstream or downstream of an AGI.

A design factor of 0.5 or less will apply in location class 2 areas where the pipeline crosses a road without casing.

A design factor of 0.5 or less will apply for all AGI piping. This includes all block valve, pigging (launcher and receiver), GMS, AGRS and compressor station piping.

In the absence of any guidance from Bulgarian ordinances, the following design factors have been assumed for other specific locations / crossings. Note that these assumptions are in accordance with the advice from the Bulgarian consultant Gastec, the requirements of EN 1594, ASME B31.8 and industry norms.

- A design factor of 0.4 will be used for the crossing of any active seismic faults. The design factor shall extend a minimum 200 m either side of each fault.
- Pipe used for HDD crossings will have a design factor of 0.4
- River and stream crossings shall adopt the same design factor as for swamp crossings (i.e. 0.6 or less).
- Where the pipeline crosses local or municipal public roads and is uncased, a design factor of 0.5 or less shall apply.
- Where the pipeline crosses private sealed or dirt tracks, a design factor of 0.72 or less shall apply.

It has been noted that the Bulgarian requirements are closely aligned with ASME B31.8.

5.6.3 Greek Location Classification Requirements

Greek location classification requirements will follow the above detailed Bulgarian requirements, with the exception that location class 3 shall be assigned to any building or area within 200 m of the pipeline where regular concentrated gatherings of people may occur, rather than 100 m. Also, the definition of "regular concentrated gatherings" remains open to interpretation on a case by case basis.

5.6.4 Greek Design Factor Requirements

Greek design factor requirements will follow the above detailed Bulgarian requirements, with the exception that Greek roads types are divided into the following categories:

- Existing or future highways and sealed public roads
- Private roads

- Unsealed roads

Different design factors apply to the above road types, depending on whether the road is cased or uncased. The design factors are similar to those used for Bulgarian roads, and are tabulated in Appendix B.

5.7 Pipeline materials

5.7.1 General

Line pipe shall be in accordance with EN ISO 3183:2012, supplemented by "Technical specification for supply of line pipes DN800 / 32". The material grade L450ME, EN ISO 3183:2012, level PSL 2 including Annex M. Both type of manufacturing process LSAW and HSAW are applicable for linepipe. Only LSAW is applicable for cold bending

The principal requirements of the linepipe specification are good weldability, consistent and close dimensional tolerances at the ends to facilitate automatic or manual welding.

For longitudinally welded pipe, the longitudinal seam shall be welded using the submerged arc welding process. The longitudinal weld metal, associated heat affected zone and the parent pipe material shall be subject to fracture toughness testing in accordance with EN ISO 3183:2012. After cold expansion and hydrostatic pressure testing the full length of the longitudinal seam weld and heat affected zones shall be subject to ultrasonic inspection in accordance with EN ISO 3183:2012.

Helical seam (spiral) pipe will be considered with the above appropriate requirements equally valid.

The final selection of pipe mill shall be determined after a detailed technical audit by an experienced pipe mill inspector, with extensive mill and field experience with both types of pipe.

5.7.2 Internal Roughness

The line pipe shall be internally lined with an epoxy lining to improve the flow properties and minimise corrosion during storage. The value for internal surface roughness, as used in the hydraulic model of the line pipe, will be assumed to be 0.0152 mm.

5.7.3 Material Thermal Properties

The thermal conductivity, specific heat capacity and density for the steel line pipe and various coatings are provided in the table below:

Concrete	Thermal conductivity	2.0 W/m.K

coating (if required)	Thickness	Refer to 10760-CLC-P0-002
	Specific heat	650 J/kg.K
	Density	2240 kg/m³ (normal density concrete) 3040 kg/m³ (high density concrete)
3-Layer PE corrosion coating	Thermal conductivity	0.5 W/m.K
	Total Thickness	3.5 mm
	Specific heat	1850 J/kg.K
	Density	940 kg/m³
Steel pipe	Thermal conductivity	50.0 W/m.K
	Thickness	As per Section 5.5
	Specific heat	500 J/kg.K
	Density	7850 kg/m³

The data utilized above has been sourced from Pipeline Simulation Software package, Perry's Chemical Engineers Handbook, 7th Edition and Borealis Group/SK Corporation Product Literature.

5.8 Pipeline Bends

Bends are required in the pipeline to accommodate changes in vertical and horizontal alignment and shall be indicated on the alignment sheets produced during the FEED.
Hot bends are provided along the route due to the steep terrain along the route, minimization of the affected property and reducing the depth of pipeline laying.

Hot Induction Bending: the minimum bend radius shall be five times the pipe diameter (5D) on all pipeline sections that will require pigging.

Cold Bending: All cold bends (field bends) shall have a minimum bend radius of 40D and shall be formed using a cold field bending machine with an internal mandrel.

The FEED will determine the quantity and bend angles for hot induction bends to facilitate long lead item procurement.

5.9 Barred Tees

Barred Tees shall be used on all pipeline sections that will require pigging. They shall meet the requirements of EN 14870-2. Tees shall be designed to allow free passage in either direction of all pig types used during typical pipeline testing, inspection and maintenance operations (including intelligent pigs). All changes in internal diameter shall be provided with a smooth internal transition.

5.10 Pipeline Leak Detection System

Pipeline leak detection and integrity monitoring requirements will be evaluated during the FEED. A SCADA (Dynamic Volume Balance, Pressure/Flow Deviations) based Leak Detection System shall be used on the IGB gas pipeline and are provided in project documents : 10760-IN-ST-01-001, 10760-PHL-PR-00-002, 10760-RPT-IN-ST-001, 10760-SPC-IN-00-008, 10760-SPC-IN-ST-005 and in the relevant parts of the Technical design. For block valves will be provided automatic shut down system.

5.11 Corrosion protection

5.11.1 External Coatings

The pipeline, valves and fittings shall be protected against external corrosion by protective coating systems.

Linepipe shall be factory coated using a 3 Layer Polyethylene (3LPE) coating system with a thickness of 3.5 mm. External coatings on two HDD crossings on Bulgarian territory is concrete coating with 50 mm thickness are provided in project documents: IGB-04-FEED-II.2.1.1.29.1 and IGB-04-FEED-II.2.1.2.52.1.
Induction bends, buried valves, fittings and other specials shall be protected against corrosion by a polyurethane coating system. The coating shall only be applied in a fully enclosed, controlled environment building.

Pipeline girth welds shall be field coated using a polyurethane coating system.

5.11.2 Cathodic protection

A cathodic protection system shall be implemented to provide protection in conjunction with the coating system. Each CP station shall include a ground-bed comprising anodes in a carbonaceous backfill, energised either by a transformer rectifier or photovoltaic unit.

The pipeline shall be isolated at the above ground/below ground transition points, tie-ins and when connecting the pipe to a device that requires electrical grounding. The isolation of the pipeline shall be via monolithic insulating joints.

Each isolating joint shall be fitted with a decoupling device to allow the flow of AC current to the grounded structures if AC fault and lightning currents have occurred on the pipeline during operation. The need for induced AC current mitigation measures shall be assessed in locations where the pipeline runs parallel to HV power cables.

5.11.3 Monolithic Insulating Joints

Monolithic Insulating Joints will be used along the pipeline length at above/below ground transition points to provide reliable electrical isolation. Monolithic insulating joints shall meet the requirements of EN 1594 and PED 97/23/EC and shall allow passage of all pigs used during typical pipeline testing, inspection and maintenance operations (including intelligent pigs). All changes in internal diameter shall be provided with a smooth internal transition.

5.12 Welding

Welding procedures and field welding shall comply with the detailed project welding specifications supplementary to EN 12732. The welding procedures shall be qualified using project pipe, bends and fittings materials. Piping and vessels for underground installations shall have only butt welded joints.

5.13 Non-Destructive Examination

All welds shall be 100% visually examined in accordance with EN 12732.

All welds shall be 100% x-rayed or 100% automatically ultrasonic tested in accordance with EN 12732.

All welds completed using Gas Metal Arc Welding Process (automatic, mechanised or manual), or cored wire welding, shall be automatically ultrasonic tested in accordance with EN 12732.

All branches, nozzles and fillet welds shall be 100% inspected using Magnetic Particle Inspection. Where fittings are attached by butt welds, the roots of the weld shall be examined from the bore by MPI where access is possible.

"Golden welds" are welds which are not pressure tested in the field and shall be 100% visually examined, 100% x-radiographed, 100% ultrasonic tested and 100% magnetic particle tested in accordance with EN 12732 and project specifications.

5.14 Pressure Testing

Pressure testing of the pipeline system shall be performed in accordance to EN 1594, EN 12327 and project specifications.

A strength test and tightness test shall be carried out. The tightness test may be combined with the strength test.

The test pressure shall be calculated in accordance with EN 1594. There may be instances when pre-testing may be appropriate (e.g. the testing of HDD strings prior to installation).

In mountainous areas the static head due to increased elevation will be considered and heavier pipeline wall thicknesses may be specified at certain locations to increase allowable test section elevation differences, and thus reduce the number of test sections required.

5.15 Depth of Cover

The pipeline shall be installed in accordance with EN1594 and the depth of cover to the top of pipe shall be a minimum of 1.0 m for the Greek section and 0.8m for Bulgarian section (in accordance with art. 34, para 1 under the Ordinance on development and safe operation of transmission and distribution gas pipelines and auxiliary natural gas facilities, installations and equipmen). The minimum depth will be increased at certain locations (e.g. rail and major road crossings), as defined in project drawings.

5.16 Crossings

5.16.1 General

The design and construction of crossings shall follow the requirements of national legislation / ordinances, relevant codes and affected third parties.

5.16.2 Watercourse Crossings

Crossing procedures shall be in accordance with all relevant ordinances, national codes and standards, so that permits from relevant authorities may be obtained.

Watercourse crossing design shall consider the following:

- River bed stability,
- River bank stability,
- River scour,
- River maintenance works (dredging, etc.),
- Future works (including bank piling, realignment, etc.),
- Ground conditions,

- Seismic activity,
- Flood zones, and
- Environmental impact.

The two major watercourse crossings (River Maritza and Studen Kladenets Lake), will be crossed using the Horizontal Directional Drilling (HDD) method. HDD installation calculations and drawings will be produced for both of these crossings. All other watercourses will be crossed via the open cut method. The exceptions are two river crossings via auger boring on the territory of Bulgaria, which are hydromeliorative facilities. Appropriate attention and mitigation (including contingency) will be given to environmental impact and pollution control as a result of the works.

5.16.3 Road and Rail Crossings

Minor roads will generally be crossed via the open cut method. Rail and major road crossings will be made via auger boring, subject to relevant authority / third party approval.

The design shall mitigate CP interference caused by third party infrastructure (e.g. electrical cables, third party CP systems, induced voltages from HV power etc.).

The minimum depths of cover at crossings shall be in accordance with national codes/ordinances and standards.

5.16.4 Service Crossings

The design of third party service crossings (e.g. water mains, gas mains, telecommunications, electrical cables, drainage pipes etc.) shall generally be via the open cut method and shall comply with third party requirements for the protection of the existing services.

Additional protection shall be considered at service crossings where there is an increased risk of damage or interference, which will be one or more of the following:

- Pipeline marker tape
- Insulating sheet between the third party service and pipeline
- Increased pipe wall thickness

A minimum vertical separation of 400 mm shall be maintained between IGB pipeline and existing third party services/structures where codes and national / local legislation and/or service owners do not specify a minimum safety distance.

5.17 Existing Pipeline Separation Distance

Where practicable the new pipeline shall be constructed parallel with existing pipeline corridors along various sections of the route. In these instances, all construction and operational risks associated with close proximity shall be taken into consideration.

Within the Bulgarian section a minimum separation distance of 28 m between an existing pipeline and a new pipeline is required in agricultural areas. This is reduced to 15 m in non-agricultural areas.

Within the Greek territory the minimum separation distance shall be in accordance with the pipeline operator's requirements and in no case shall be less than 3 m. For gas or hazardous liquid pipelines a minimum separation of 10 m is recommended.

5.18 HDPE Conduit

Telecommunications with block valve stations will be via Fiber Optic Cable (FOC). The FOC shall be installed in a High Density Polyethylene (HDPE) conduit.

On the Greek territory the FOC will be laid in the trench of the gas pipe. On Bulgarian territory the FOC will be installed in a separate trench at a distance of 7 m on the right side of the gas pipeline axis.

Two HDPE conduits will be installed in parallel to the pipeline on Greek territory.

Three HDPE conduits will be installed in parallel to the pipeline on Bulgarian territory– two of them at distance of 7m (main and backup) and the third in the trench of the gas pipe.

5.19 Pipeline Trench

5.19.1 Trench Design

The trench for pipeline installation will be excavated in accordance with international practices. The depth and width of the trench will be designed to provide sufficient space for proper pipe laying, compaction of bedding, padding and backfill material. The pipeline trench will be sufficiently deep to provide the required minimum depth of cover.

Depending on local geology and soil conditions the trench wall slope will be adjusted to ensure trench wall stability during construction. In areas where a high water table is encountered trench dewatering and drainage measures will be foreseen. The pipeline trench cross section will be modified at locations where special pipeline protection measures are required (e.g. active fault crossings).

The pipeline trench design will be elaborated in the relevant project standard drawings and specifications. Local conditions including ease of

excavation, stability and compressibility of soil, as well as underground water table and existing networks will be adequately accounted for in the drawings and specifications.

5.19.2 Backfilling

The pipeline trench fill will, in general, consist of bedding, padding and backfill material.

The bedding course will provide adequate and uniform support conditions for the foundation of the pipeline to be laid. Padding will provide complete encasement of the pipeline within a protective cushion of fill material. In general, clean natural or quarry sand will be used for the construction of bedding and padding courses, except in areas where suitable select trench excavation material is available for that purpose.

Pipeline warning and identification mesh or concrete flagstones will be provided in accordance with project drawings to indicate the location of the pipeline.

Backfilling of the pipe trench will provide adequate cover to the pipeline and will be designed to avoid undesirable settlements at the ground surface. In general, backfill material will consist of selected trench excavation material, except in road crossings where graded quarry aggregates will be specified.

Special fill materials and fill construction methods will be specified where pipeline protection measures are required (e.g. active fault crossings).

Pipeline trench fill materials, compaction requirements and fill construction methods will be fully specified and will cover all cases in the relevant standard drawings and specifications to be developed.

5.20 Additional Protection Measures

Special pipeline protection measures will be designed and specified where required to guarantee the integrity of the pipeline along the route. Such measures will be installed in the following locations:

- Crossings with roads and motorways
- Crossings with railways
- Crossings with rivers, ravines and streams
- Crossings with third party services
- Areas with erosion potential (e.g. steep slopes)
- Crossings or parallel routing with active seismic faults
- Locations with potential slope instability problems
- High water table and muddy areas

In these locations pipeline protection measures will include, but not be limited to, the following:

- Additional depth of cover
- Specified minimum separation distance from third party service
- Pipeline marker mesh
- Concrete slabs and flag stones
- Pipeline casings (as required by Greek and Bulgarian legislation)
- Increased wall thickness
- Increased coating thickness (at HDD crossings)
- River, or ravine, bed erosion protection
- River, or ravine, bank erosion protection
- Slope drainage and stabilisation measures
- Special pipeline backfill
- Surface and subsurface erosion protection measures in sloped terrain
- Buoyancy control measures

Pipeline protection measures, associated construction methods and materials will be specified in standard drawings and specifications.

6. Block Valve and Pigging Stations

6.1 Block Valve Stations

Block valves shall be installed on the pipeline for the purpose of isolating the pipeline for maintenance and emergency response. Block valve stations shall incorporate a bypass for use during commissioning, maintenance or emergency operations.

The separation distance between Block Valves within Bulgaria shall be in accordance with EN 1594 and shall not exceed 30 km.

Pipeline block valves will be gas over oil actuated with weld ends and pups designed for welding directly to the adjacent linepipe. Valves shall be buried and the actuator installed above ground within a secure fenced compound.

6.2 Pipeline Pigging Stations

Pigging stations incorporating permanent bi-directional pig traps shall be installed at each end of the pipeline at the above ground facilities at Komotini and Stara Zagora.

The pig traps shall be designed for bi-directional operations and therefore launchers and receivers will be identical.

The design shall consider the anticipated maximum length of cleaning and inspection pigs which may be used during future operations and the pig traps shall be sized accordingly.

Each pigging stations shall include the following:

- Weld end permanent bi-directional pig trap with quick opening closure
- Above ground full bore weld end isolation valve
- Above ground off-take barred tee
- Above ground isolation joint for electrical isolation of the pipeline Cathodic Protection system
- Above ground off-take valve
- Kicker line with isolation valve
- Balance line with isolation valve
- Pressure relief valve connected to the vent stack for overpressure protection with a by-pass for the blowdown of pig trap and depressurising / degassing of pipeline

- Pig signaller to indicate the passage of pigs into or out of the trap
- Drain line in order to drain off liquid moved through the pipeline by pigs
- Nitrogen connection to purge the pig trap and ancillaries

7. Gas Metering and Automated Gas Regulating Stations

7.1 General

Gas flow and pressure shall be controlled and metered at all input and output points of the IGB Pipeline System for system control and custody transfer purposes.

The stations shall be designed generally in accordance with EN 1776 – 'Gas Supply – Natural Gas Measuring Stations – Functional Requirements' and EN 12186 – 'Gas Supply Systems – Gas Pressure Regulating Stations for Transmission and Distribution – Functional Requirements'.

7.2 Filtration

The natural gas will enter the station and shall be conditioned by means of horizontal, two stage filter-separator units that will remove solid particles and liquid droplets that might be present in the incoming gas. The filter-separator units will consist of identical runs mounted on common inlet and outlet headers and will be equipped with liquid holding capacities that can be manually drained into the draining system.

The number of installed filter-separators is foreseen to follow an "n+1" sparing philosophy. Stub-outs will be included for installation of further units if required. Inlet and outlet valves will allow the filter separators to be isolated. Filters can be by-passed.

7.3 Gas Pre-heating

Gas pre-heating units are located downstream of filtration. The pre-heaters are used to prevent low gas temperature at station outlet due to the pressure drop through the downstream regulating valves and therefore to prevent freezing of the downstream line or hydrates or condensate/water formation. Gas pre-heaters will be bypassed when the pressure drop across the downstream regulating valves is low and pre-heating is not required.

Gas pre-heaters at each station will be installed in pairs (1 duty, 1 stand-by), with common inlet and outlet headers. The headers will have flanged ends to enable easy installation of additional heaters for any future station capacity increase.

With the exception of the Kardjali AGRS, station gas pre-heaters will be heat exchangers with hot water supplied via a separate hot water package. At the Kardjali AGRS, lower but mainly continuous heating requirements will enable the use of a gas fired water bath heater.

7.4 Gas Composition and Quality

A gas analysis system shall be located downstream of the regulating section for continuous determination and recording of gas composition and quality. Gas chromatographs will measure gas component concentrations. Dew point measurement shall be included.

7.5 Flow and Pressure Control

Pressure and flow control will be achieved by automatic flow control valves using a duty / stand-by stream configuration suitable for achieving maximum security of supply whilst maintaining the safety of the downstream system. Control modes will include volumetric control with high / low pressure overrides, direct valve control and pressure control. A high capacity, low differential pressure stream will be included for operation when the station differential pressure is very low. Gas pre-heating will be provided where required to ensure adequate downstream gas temperatures are maintained.

Stub-outs are provided for installation of future runs.

7.6 Metering

The gas flow is measured by a custody transfer metering system before the gas is directed to the regulating system.

The flow metering system will be composed of several parallel meter runs. The number of installed flow meters is foreseen to follow an "n+1" sparing philosophy. Stub-outs will be included for installation of further units if required. Inlet and outlet valves will allow the meters to be isolated.
Two metering lines are forseen at GMS Komotini Dn600(24")(one in operation and one spare),whereas each metering line is equipped with one bi-directional ultrasonic flow meter.
Three metering lines are foreseen at GMS Stara Zagora (two in operation and one spare) Dn300 (12") (IGB-04-FEED-III.3-DAT-IN-A2-013) whereas each metering line is equipped with one bi-directional ultrasonic flow meter.

Fiscal USMs shall be Class 1 meters as defined in ISO 17089-1 and shall meet or exceed ISO 17089-1, Measuring Instruments Directive 2004/22/EC and AGA report No. 9 performance specifications with a system uncertainty (mass flow) < ±1.0%, total USM uncertainty < ±0.7%, repeatability < 0.2%, resolution < 1 mm/s and maximum peak to peak error of 0.7%.

From the above any total metering system error shall not exceed +/- 1.0% over the full operating range.

Explosion safety design is compulsory, with all equipment installed in hazardous areas Ex-Certified.

All fiscal/custody transfer metering systems shall have multiple meter runs with a calibration regime in place. Gas chromatographs shall be an integral part of the fiscal / custody transfer metering and shall be used to derive physical properties used in the metering system.

Metering data shall be transferred to the SCADA system via the local Station Control System and shall be available at Dispatch Centre / Operational and Maintenance Base.

To maximise efficient construction and installation, the approach to the mainline and off-take fiscal gas flow metering shall be to provide the flow meters, valves and gas chromatographs, pressure and temperature transmitters as a compete skid mounted package supplied with two flow computers installed on each run and associated equipment mounted in cabinets to be located in metering station control rooms.

This will provide a fully integrated system of an approved design, that shall be tested, delivered to site and calibrated (across the complete operating pressure range), and come complete with all the required documentation to enable the project team to complete the hook-up with the minimum of input.

7.7 Piping Design

Process gas piping for the stations shall be designed in accordance with EN 1594, with the exception of low temperature process gas piping (blowdown vents - downstream of the last isolation / throttling valve), which will be designed in accordance with EN 13480. Station utility piping shall be designed in accordance with EN 13480.

7.8 Utilities

7.8.1 Nitrogen

Nitrogen will be utilised for the continuous purge of closed drains and venting systems and for inerting natural gas piping and equipment during maintenance or system shutdown of each GMS and AGRS.

The Nitrogen supply system comprises two sources; a bottle rack equipped with a pressure reduction system and a Nitrogen production package capable of operating both continuously and intermittently.

The Nitrogen production package shall comprise of two (duty/standby) air compressors, one water knock-out drum, two nitrogen generator streams (duty/standby) and one nitrogen buffer drum.

7.8.2 Fuel Gas

Fuel gas packages are used for the supply of conditioned natural gas to the hot water heaters.

Each fuel gas package shall have a fuel gas in-line filtration system, fuel gas heaters, a fuel gas pressure reduction system and a control and protection system.

The gas flow rate shall be metered by one 100% capacity meter located downstream of filtration, heating and pressure regulation.

7.8.3 Hot Water System

Hot water systems are installed at stations with gas pre-heater heat exchangers.

Each hot water system comprises of a duty and stand-by hot water boilers and one water storage tank.

The hot water system shall have one hot water expansion drum, two hot water pumps (2x100%), two water heaters (2x100%) and connections to the fuel gas system.

The water heater package shall be constructed on a welded structural steel skid housed in a boiler room.

The water storage tank is used as a buffer supply and for collecting discharge from pressure relief valves. The tank shall be fitted with a pump to enable filling of the water circuit, mixing of the glycol/water solution and unloading of the tank itself.

7.9 Noise Levels at AGIs

7.9.1 General Requirements

The following noise limit requirements will be satisfied for both Greek and Bulgarian pipeline facilities.

Noise limits will be in accordance with Directive 2003/10/EC of the European Parliament and the Council of the European Union. Directive 2003/10/EC provides definitions for noise measurement parameters as follows:

- Peak sound pressure (p_{peak}): maximum value of the "C" frequency weighted instantaneous noise pressure.
- Daily noise exposure level ($L_{EX,8h}$): time weighted average of the noise exposure levels for a nominal eight hour working day as defined by in ISO 1999. It covers all noises present at work, including impulsive noise.
- Weekly noise exposure level ($L_{EX,8h}$): time weighted average of the daily noise exposure levels for a nominal week of five eight hour working days as defined by in ISO 1999.

Using the above noise measurement parameters, Directive 2003/10/EC sets the following exposure limit and exposure action values:

- Exposure limit values: $L_{EX,8h}$=87 dB(A) and p_{peak}=200 Pa (140 dB(C) ref. 20 μPa).
- Upper exposure action values: $L_{EX,8h}$=85 dB(A) and p_{peak}=140 Pa (137 dB(C) ref. 20 μPa).
- Lower exposure action values: $L_{EX,8h}$=80 dB(A) and p_{peak}=112 Pa (135 dB(C) ref. 20 μPa).

When applying the exposure limit values, the determination of a worker's exposure shall take account of the attenuation provided by individual hearing protection worn by the worker. The exposure action values shall not take account of the effect of any such protection.

In locations where noise exposure varies significantly from day to day, the weekly noise exposure level may be used in place of the daily noise exposure level, provided the specific requirements detailed in Directive 2003/10/EC are met.

For sound power level measurements the reference sound power will be 10^{-12} W. For sound pressure level measurements the reference pressure level will be 20 μPa.

In areas where the workers will be exposed to noise exceeding the lower exposure action values, hearing protection shall be made available to workers.

In areas where the workers will be exposed to noise exceeding the upper exposure action values, appropriate warning signage, area demarcation and entry restrictions (including mandatory hearing protection), will be instated.

Under no circumstances shall worker exposure exceed the exposure limit values.

7.9.2 Specific Greek Requirements

In addition to the above general requirements, the following plant boundary noise limits will apply in Greece.

As per Greek Regulation P.D no. 1180/81, issued with Φ.Ε.Κ. 293 dated 6/10/1981, the sound pressure levels at AGI boundaries will be lower than the values tabulated below. Sound meters will be used on the SLOW response setting.

Location	Sound Pressure Level Limit
Purely industrial areas.	70 dB(A)
Areas with industrial installations prevailing.	65 dB (A)
Areas with industrial installations and residential districts.	55 dB (A)
Areas with residential districts prevailing.	50 dB (A)

7.9.3 EIA Noise Requirements

In addition to the above noise limits, all limits specified in the final project Environmental Impact Assessment (EIA) shall be adhered to. If the EIA limits are more stringent than those detailed in the above sections, then the EIA requirements will be used.

7.9.4 Noise Limits for Individual Equipment Items

Equipment will be specified with consideration given to the minimisation of noise emissions. If necessary, equipment will be supplied with acoustic attenuation to ensure station noise requirements, as detailed in the above sections, are met.

Detailed individual equipment item noise limit requirements are provided in the project Specification for Noise Control (10760-SPC-ME-00-103) and the designer has considered the requirements under Hygiene Norm № 64 on the Maximum allowable noise levels on the territory of Bulgaria applied in the relevant parts of the Technical design.

8. Civil Works for Block Valve, AGRS and GMS Stations

8.1 General

All AGI stations civil works required for the realization of the project, including site preparation, earthworks, reinforced concrete works, steelworks, site drainage, buildings and access roads, will be designed in accordance with the latest editions of the applicable codes and standards listed in project document 10760-LST-EN-00-001 "List of Applicable Norms and Legislation" and in compliance with project specific civil work job specifications and List of Applicable standards applied in the relevant parts of the Technical design.

8.2 Building Terms and Associated Clearances

The plot plan of Block Valve Stations, Automated Gas Regulating Stations and Gas Metering Stations has been prepared taking into consideration minimum plan clearances between new installations, and between new installations and existing installations and infrastructure, or property limits. Station installations satisfy the clearances derived from applicable Bulgarian or Greek building terms legislation, depending on the location of each station. In case of multiple clearance requirements, including safety requirements defined elsewhere, the most stringent will apply.

8.3 Site Preparation & Earthworks

The property area of AGIs will be cleared of vegetation and the top soil will be stripped. Apart from providing a sound foundation to near surface construction works, top soil stripping will serve to inhibit growth of vegetation and minimize the risk of fire initiation inside the station, or spread of external forest fires to the station, which could jeopardise the pipeline installation.

Site selection will identify flat sites for AGIs in an effort to minimize required earthworks, civil works and provide reasonable access to the site. When this is not possible, site levelling may be required to flatten or raise the station area.

Site levelling and grading will be accomplished by excavation and/or backfilling depending on site topography. Slope stability will be achieved by providing a safe inclination to the natural slopes (excavated) and artificial embankments (backfilling). Fill material will be selected excavation material conforming to project specifications, or quarry sand gravel when suitable material is not available.

When site topography limitations and/or available plot area inhibit the construction of slopes, cantilever reinforced concrete retaining walls will be provided to support site level differences.

8.4 Station Buildings

8.4.1 RCC Buildings

A separate RCC building will be provided at every Block Valve Station, when these Stations are not located in the same plot area with an AGRS or GMS Station.

The RCC building will be a steel, prefabricated, vendor supplied house. The house shell shall be fire-proof and thermally insulated. Roof will provide adequate water drainage. Roof rainwater will be discharged directly to surrounding area without drain pipes.

Entrance to the RCC building will be provided through a lockable steel door, large enough to permit entry of the largest single item of equipment. The floor inside the enclosure will be elevated at least 300 mm above the highest point of the finished ground elevation. Floor finish will consist of anti-static resilient flooring.

A reinforced concrete slab on grade foundation shall be provided to support the RCC building. The foundation will extend minimum 0.20m above the finished ground elevation. The foundation will be placed on a compacted quarry aggregate base course.

The prefabricated RCC building shall be fixed to the foundation with post installed anchor bolts.

8.4.2 Station Control/Utilities Building at Komotini

The load bearing system of the building will be a conventional cast in-situ reinforced concrete frame consisting of columns and/or shear walls, beams and roof slabs of continuous monolithic construction.

The foundation of the building will consist of a cast-in-place reinforced concrete strip foundation, or pad foundations with connecting beams.

The control/utilities building will be a single storey building with sufficient plan dimensions and height to accommodate all utilities required for station operation. The control/utilities building will accommodate the following.

- Control room
- Room for the boiler package
- Low voltage switchboards
- UPS and battery room
- Utility Room
- WC

The building roof will be thermally insulated and waterproofed. Access to the roof of the building will be through a vertical steel ladder with

safety cage. Roof rainwater to be collected and discharged at ground level by galvanised steel pipe drains.

External and internal partition walls will be constructed from hollow clay brick masonry. External building walls will incorporate thermal insulation. The building facade will consist of decorative bricks in recess alternating with fair faced concrete of the building frame.

Where required, openings will be provided on external building walls to provide adequate cooling, air supply and ventilation of installed equipment. For the same reasons louvers will be incorporated in external building doors, as required. Where natural lighting is required windows will be installed.

The utility building floor will consist of concrete paving with industrial flooring. The concrete floor will be cast on a suitably prepared crushed aggregate base course. An antistatic raised floor will be provided for the control room. The building ground floor level will be raised above final ground elevations outside the building to avoid ingress of storm water. Access to the building at ground floor level will be through steel doors.

8.4.3 AGRS and GMS Station Control Houses

There will be a Control House at the AGRS and GMS Stations.

The Control House enclosure will be a steel prefabricated, vendor supplied house for GMS on Greece territory and steel construction fabricated on site for Bulgarian part. The house shall be fire-proof and thermally insulated. Roof will provide adequate water drainage. Roof rainwater will be discharged directly to surrounding area without drain pipes.

Entrance to the Control House will be provided through a lockable steel door large enough to permit entry of the largest single item of equipment. The floor inside the enclosure will be at least 300 mm elevated above the highest point of the finished ground elevation. Floor finish will consist of anti-static resilient flooring.

A reinforced concrete slab on grade foundation shall be provided to support the Control House. The foundation will extend minimum 0.20 m above the finished ground elevation. The foundation will be placed on a compacted quarry aggregate base course.

The prefabricated Control House shall be fixed to the foundation with post installed anchor bolts.

8.4.4 AGRS and GMS Boiler Houses

There will be a Boiler House at the Stara Zagora GMS and Dimitrovgrad AGRS.

The Boiler House enclosure will be a steel prefabricated,vendor supplied house for GMS on Greece territory and steel construction fabricated on site for Bulgarian part. The house shell shall be fire-proof and thermally insulated. Roof will provide adequate water drainage. Roof rainwater will be discharged directly to surrounding area without drain pipes.

Entrance to the Boiler House will be provided through a lockable steel door large enough to permit entry of the largest single item of equipment. The floor inside the enclosure will be at least 300 mm elevated above the highest point of the finished ground elevation. Floor finish will consist of anti-static resilient flooring.

A reinforced concrete slab on grade foundation shall be provided to support the Boiler House. The foundation will extend minimum 0.20 m above the finished ground elevation. The foundation will be placed on a compacted quarry aggregate base course.

The prefabricated Boiler House shall be fixed to the foundation with post installed anchor bolts.

8.5 Station Internal Roads and Paving

Station internal roads will provide access to all station facilities and buildings. Where future installations are foreseen, the internal road layout will allow for future expansion and interconnection.

A paved area will be provided to allow vehicle manoeuvring and enable pigging operations to be carried out safety.

At metering and regulating stations a concrete paved area shall be provided behind gas filter separators to facilitate filter cartridge removal for maintenance or replacement. The Gas pre-heaters shall also have allowance for a concrete paved area behind the Gas Heat Exchangers for tube bundle removal/maintenance.

Internal roads will be minimum 5 m wide. At turns, internal roads will have a minimum turning radius of 7.5 m measured on the road axis to allow circulation of a medium sized truck.

Road construction will be asphalt paving consisting of minimum two courses, an asphalt binder course and a wearing course. At remote stations where access of asphalt paving equipment is difficult or uneconomic, internal site roads will be constructed with heavy duty concrete paving.

Asphalt paved internal roads will be laid on a prepared base course consisting of two layers of quarry sand-gravel with the minimum thickness and compaction requirements specified in relevant project specification.

8.6 Gravel Surfacing

Gravel surfacing is foreseen in areas where natural gas piping is installed in pipeline Block Valve, AGRS and GMS Stations.

Gravel surfacing will cover the entire internal area defined by the piping assembly of the Station (including vent stack) and will extend minimum 3 m beyond the external limits of these areas. Where feasible, based on economic considerations, gravel surfacing will be extended to the edges of internal station roads or fence.

Gravel surfacing will consist of loose clean quarry gravel grading 32/16 mm and will be minimum 150 mm thick.

8.7 Access Roads to Stations

Access to all stations will be ensured by the construction of new access roads, or by improvement of existing tracks. Access roads will connect the stations to the existing road network of the particular area and their length will be minimised to the extent possible by site selection.

Access roads will be 5 m wide minimum and will be paved with asphalt that will be constructed with minimum two courses, an asphalt binder course and a wearing course. A stabilised shoulder will be provided on each side of the road.

The access roads will be laid on a prepared base course consisting of two layers of quarry sand-gravel with the minimum thickness and compaction requirements specified in the relevant project specification.

Where steep topography is encountered downhill of the road and at changes of road direction, steel safety barriers will be provided.

Road section surface profile will be inclined towards the two outer road limits. Minimum transverse slope will be 2.5%.

In flat terrain access roads will be constructed on an embankment of sufficient height to avoid flooding and ensure proper drainage of the access road on either side.

In mountainous terrain, where the road runs perpendicular to the natural slope and steep topography is encountered, road construction will be entirely in the excavated slope. Otherwise, if mild slopes are encountered, which permit stable fill construction, the road may be partially laid on fill. In both cases proper road drainage requires construction of concrete gutter uphill of the road section. Culverts will be foreseen along the low points of the longitudinal road section to allow downhill draining of the concrete channel along natural water courses.

8.8 Storm-water Drainage

Storm-water drainage of stations will be ensured mainly by surface flow directed outside property limits. Use of drainage channels and storm-water conduits will be restricted to exceptional cases where surface drainage alone is insufficient.

For the purpose of providing site drainage, station and road levels will be established such as to provide a minimum slope of 1% to 2% towards natural water courses at property limits.

In flat terrain, station elevations will be raised above those of surrounding property to avoid flooding and ensure that the minimum surface inclinations can be realised.

The height of the strip beam at the base of fencing will be increased as required to inhibit rainwater ingress from neighbouring property. At low points along property limits the strip beam will be interrupted locally to allow drainage of rainwater runoff outside property limits.

Draining of retaining wall backfill will be foreseen as required to avoid accumulation of pore water pressures and ensure surface water drainage behind the wall. Drainage behind walls is to be provided in the form of permeable geosynthetic membrane placed in contact with the wall. Accumulated water will be drained via weep holes provided along the length of the retaining wall.

8.9 Station Fencing and Gates

Each station will be contained by a High Security – Anti Intruder fence along property limits. The fence will be robust and will be constructed of high tensile heavy gauge chain link fabric supported by galvanised steel posts at regular intervals. The posts will incorporate Y-shaped extension arms holding a concertina razor blade coil and shall be fixed to a shallow concrete pile foundation. Total height of the high security fence will be 3 m for AGI on Greece territory and 2,7m for AGI on Bulgarian part.
The main entrance gate of the station will be located at the property side facing the access road. At the main entrance gate of the station the corresponding fence line, which runs parallel to the access road, will be placed 5 m inside of the property limit. On all other sides of the property the perimeter fence will be placed on the property limit.

Main entrance gate will consist of a double leaf vehicle gate 6 m wide and a single leaf personnel gate 1 m wide arranged side by side. A single personnel emergency exit gate will be placed on the opposite side of the fence relative to the position of the main entrance gate. Personnel emergency exit gates will be 1 m wide for Greece part.

The main entrance gate of the stations will be located at the property side facing the access road.

A sliding fence door with rail mechanism will be located at the west side of the fence of the station Stara Zagora and at the north side of the fence of Dimitrovgrad and at the south side of the fence of the station Kardjali and will have clear opening of 4.50 m.

Block valve stations' main entrance gate will consist of a double leaf vehicle gate 4 m wide. Personnel emergency exit gates will be 1 m wide at the opposite side.The respective part of the Technical Design describes in details the requirements for the Bulgarian section.

8.10 Miscellaneous Civil Works

Civil and structural works for AGIs will also include the following structures:

- Reinforced concrete foundations for pipeline underground valves, bends, tees etc.
- Pig Launcher/Receiver reinforced concrete foundations
- Vent stack steel supporting structure and reinforced concrete foundation
- Vendor package foundations
- Storm-water drainage
- Aboveground pipe support foundations
- Civil works for underground cable and utility networks

8.11 Structural Design

8.11.1 General

Structural design parameters, such as design actions and loads, load combinations, safety factors, material properties etc. will be in compliance with project codes and standards, listed in project document 0760-LST-EN-00-001 "List of Applicable Norms and Legislation" and List of Applicable standards applied in the relevant parts of the Technical design.

Structural design of all buildings, foundations, structures retaining walls, etc. shall be based on the structural Eurocodes and relevant EN Standards. Where local laws and regulations prohibit the use of structural Eurocodes, the country specific national codes and standards shall apply.

8.11.2 Design Life

All civil works for the project will have a design life of 50 years.

8.11.3 Permanent Loads

Permanent loads will include dead loads of structures (structural materials, floors, stairs and all permanent materials forming part of the structure), equipment loads and piping weights. Minimum values for

design will be specified in detail in the relevant project specification for civil design loads.

8.11.4 Variable Actions

Actions imposed to structures due to the operation of equipment, environmental actions such as thermal actions, wind actions and snow loads, live loads due to traffic, storage or use, earth pressures acting on underground structures and any other variable (not permanent) action will be accounted for in the structural design. Minimum design live load values will be specified in detail in the relevant project specification for civil design loads.

8.11.5 Earthquake Actions

The seismic design of buildings and structures will comply with either Eurocode 8 or Ordinance No Rd-02-20-2 of 27th of January 2012 for the Design of buildings and structures in earthquake areas for structures located in Bulgaria, and the Greek Seismic Design Code (EAK 2000) for structures located in Greece.

Seismic loads have been determined based on seismic response spectrum parameters, such as seismic zone, peak ground acceleration, soil class, importance factor, behaviour factor, damping and spectral amplification factor, as defined in the relevant seismic codes.

Buildings or structures have been given importance category IV in accordance with EN 1998-1 or Ordinance No.2 2007, and importance class Σ4 in accordance with EAK 2000.

Seismic loads for design will be specified in more detail in the relevant project specifications and calculations.

8.11.6 Accidental Actions

Accidental actions, other than seismic actions, will be considered according to the requirements of structural Eurocodes.

8.12 Heating, Ventilation and Air Conditioning (HVAC)

8.12.1 General

HVAC systems shall be designed, manufactured and tested in accordance with applicable project norms and legislation, as provided in the project document List of Applicable Norms and Legislation: 10760-LST-EN-00-001 and List of Applicable standards applied in the relevant parts of the Technical design.

The HVAC system shall be designed according to each building / house geographical site location climatic conditions. Greek or Bulgarian regulations for external climatic conditions shall be followed. The HVAC design shall be adequate to function in the design ambient conditions listed in Section 4.10.

The HVAC installations will be designed to ensure:

- Safety to personnel and equipment
- Reliability of the HVAC system

8.12.2 RCC Buildings

The following requirements shall be taken into account for the HVAC system design:

Heating and Cooling shall be provided in order to maintain a constant temperature of 20°C in winter and 24°C in summer. The HVAC system shall be adequately sized to maintain the above internal conditions, with ambient conditions referred in national Greek or Bulgarian Regulations (depending on site of installation).

The maximum internal temperature shall not be higher than +35°C in summer at highest external design temperature. Also the minimum internal temperature shall not be lower than +15°C in winter at minimum external design temperature

8.12.3 AGRS and GMS Station Control Houses

The following requirements shall be taken into account for the HVAC system design:
Heating and Cooling shall be provided in order to maintain a constant temperature of 20°C in winter and 24°C in summer. The HVAC system shall be adequately sized to maintain the above internal conditions, with ambient conditions referred in national Greek or Bulgarian Regulations (depending on site of installation). The maximum internal temperature shall not be higher than +35°C in summer at highest external design temperature. Also the minimum internal temperature shall not be lower than +15°C in winter at minimum external design temperature.

8.13 Fire Fighting

8.13.1 General

The fire fighting system shall be designed, manufactured and tested in accordance with applicable project norms and legislation, as provided in the project document List of Applicable Norms and Legislation: 10760-LST-EN-00-001 and List of Applicable standards applied in the relevant parts of the Technical design.

The fire fighting installations will be designed to ensure:

- Safety to personnel and equipment
- Reliability of the Fire Fighting system
- Ease of maintenance and convenience of operation

8.13.2 RCC Buildings

The fire fighting system will consist of:

- An autonomous, self-governed INERGEN fire suppression system
- Fire extinguishers such as portable chemical dry powder extinguishers & CO_2 extinguisher

8.13.3 AGRS and GMS Station Control Houses

The fire fighting system will consist of:

- An autonomous, self-governed INERGEN fire suppression system
- Fire extinguishers such as portable chemical dry powder extinguishers & CO_2 extinguisher

9. Electrical Equipment for Block Valve, AGRS and GMS Stations

9.1 General Requirements

The design, manufacture, testing and installation of the electrical equipment at the stations will be in accordance with the latest edition of applicable codes and standards listed in project document 10760-LST-EN-00-001 "List of Applicable Norms and Legislations" and in compliance with project specific electrical job specifications. For Technical design - List of Applicable standards applied in the relevant parts.

The electrical installations will be designed to ensure:

- Safety to personnel and equipment
- Reliability of the electrical system
- Ease of maintenance and convenience of operation
- Future load requirements

Due regard will be given to the system short circuit levels and protection requirements.

The electrical distribution equipment design will include 20% spare capacity to size the system for the most onerous load demand, together with allowance allow for future additions.

Electrical equipment normal and fault condition parameters will be signalled to the Central Control Facility located at the Dispatch / Operational and Maintenance Base.

All electrical equipment will be suitable for the particular environment in which it is installed.

9.2 Hazardous Area Classification

Areas will be classified in accordance with: EN 60079-10 Classification of hazardous areas for explosive gas atmospheres.

All electrical equipment located in a hazardous area will have European standard area certification be ATEX certified, in the following order of preference:

Zone 1

EExe - Increased safety.
EExd - Flameproof.
EExp - Pressurised.

Zone 2

As Zone 1 or

EExic - Intrinsically safe

Electrical equipment for hazardous areas will be certified for Gas Group IIA and Temperature Class T3.
Electrical equipment located in a hazardous area will have an enclosure applicable to the particular zone, but wherever possible, electrical equipment will be located outside of a hazardous area.

Where appropriate (low power, voltage and current), the connections between the electrical equipment located in hazardous and safe area will include certified EEx safety barriers.

In no circumstances will equipment be installed to a lesser certification than that required by the hazardous area.

9.3 Electricity Supplies

All facilities' electricity supplies will be provided by the local utility grid where practicable. Where suitable supplies are not available locally then on site generation will be considered.

9.4 Emergency Power Supply System

A standby diesel generator with a daily diesel tank and its control panel will be installed at the Komotini and Stara Zagora Gas Metering Stations and at the Dimitrovgrad Automated Gas Regulating Station, Kardjali AGRS and Dispatching center (OM Base) to maintain emergency loads, in case of fault of mains power supply from the local utility grid via an automatic transfer system. The emergency diesel generator will be installed outdoors.

Under normal conditions the main switchboard inside each RCC building in Block Valve and / or Pigging Stations will be supplied by the local utility grid. Whereas, under abnormal conditions, it will be supplied by the emergency power supply system (i.e. emergency portable diesel generator) through an incoming socket suitable to supply all loads, which will be fitted on the external side of RCC building.

9.5 Uninterruptible Power Supply (UPS)

The UPS (in each Block Valve and / or Pigging Station and Metering / Gas Regulating Station) will be provided to supply essential control, monitoring, communication and security systems at each facility in the event of an electricity supply failure.

Batteries will be lead acid, sealed type, sized to provide a time of 12 hour autonomy to the critical loads for Block Valve Station and 4 hour autonomy for GMS Stara Zagora, AGRS Dimitrovgrad and Kardjali and Dispatching center(OM Base).

UPS and batteries for each Block Valve Station and Metering Station will be installed in RCC building or Metering / Gas Regulating Station Control House, respectively.

9.6 Switchboards

A main normal and a main emergency low voltage switchboard will be installed inside each Station Control House, in order to feed electrical loads. Normal and emergency sub-distribution switchboards will be installed for feeding lighting and power loads. UPS and process loads (other than critical) will be fed by emergency sub-distribution switchboards.
Whereas, in each RCC building, the main switchboard will be supplied either by the local utility grid or by the emergency power supply system, as above mentioned.

UPS sub-distribution switchboards will be installed in RCC building and Metering / Gas Regulating Station Control Houses for feeding the electrical critical loads.

9.7 Cabling

Cables will be stranded copper conductors, XLPE insulated, steel wire armoured and PVC over-sheathed.

Underground cables will generally be directly buried, with protective concrete covers and danger warning tape.

Concerning cables crossing roadways, they will run in duct banks suitable to withstand road traffic.

Above ground cables will run inside hot dip galvanised cable trays with covers and / or hot dip galvanised conduits.

Segregation of power cables, low current cables other than the ones of intrinsically safe circuits and cables of intrinsically safe circuits will be provided. Where crossovers between power and instrument cables are unavoidable then these will be made at right angles and distance.

9.8 Lighting and Small Power Supply System

A complete lighting and power supply system will be provided in each Station.
The outdoor lighting circuits will be controlled through auto-off-manual selector, by outdoor photocell.

Indoor lighting will be provided by fluorescent luminaries.
Lighting fixtures and lamps will be of the high efficiency type (where applicable).

9.9 Earthing and Lightning Protection System

9.9.1 Earthing Design

An earthing and bonding system to earth in each Station will be provided to ensure safety to personnel, earthing for operational reasons and protection against static electricity. An earthing and bonding system to earth is also necessary for electric / electronic instrumentation and communication system, as well as for protection against lightning.

Above ground pipeline and piping system will be earthed, in case that it is electrically isolated from the underground one.

A common earthing system will be provided in each Station for all earthing purposes, unless otherwise specified.

Each earthing arrangement will consist of an earth termination system, earthing conductors and earthing terminals or earthing bars.

Spark-gaps will be installed, if required.

A foundation earthing will be constructed in each Station and other earth electrodes will be added (if required), so as that resistance of earthing system should be low.

9.9.2 Lightning Protection System Design

The selection and the necessity of installing a Lightning Protection System arrive after performing the risk management according to the standard EN 62305-2.

Lightning Protection System will comprise External and Internal one.

External lightning protection system will consist of the following:

- Air Termination System
- Down conductors
- Earth termination system

Internal lightning protection system will comprise Surge Protective Devices.

10. Dispatching Centre / Operations and Maintenance Base

10.1 Buildings and Functional Requirements

10.1.1 General

The main functions identified for the IGB O&M base are:

- Monitoring, control and operation of the IGB pipeline from a dedicated control room
- Provide base for field maintenance and patrol crews
- Provide basic maintenance and repair facilities of pipeline components including pipes, pipe fittings, pipeline instruments and cathodic protection equipment.
- Provide warehouse facilities for pipeline spare parts
- Provide office space and facilities for technical and administrative personnel

In order to cover the above functions the manpower requirement of the IGB O&M base is approximately 32 employees.

In the sections that follow building requirements are established which accommodate the above facilities and provide the required working space for the O&M base personnel. It is estimated that implementation of the O&M base requires a property of approximately 10,000 m^2.

10.1.2 Office / Control Building

- The Office / Control Building of the O&M base will accommodate the following facilities and activities:Automated gas distribution stations
- Telecommunications and ACS (Automated Control System)
- instrumentation and controls
- Executive, supervisor, personnel, accounting, engineer and traffic control offices
- Training / Meeting Room
- General archive room
- Kitchenette and dining area
- Toilets
- Building utility rooms and storage rooms

The main function of the building is to serve and manage the processes and actions, performed to the main gas pipeline and to create normal conditions for work and rest of the staff.
The office building is single storey and comprises of three buildings arranged in parallel, but shifted relatively to each other. Two of the volumes are solid and of broad area; the offices and premises necessary for the Dispatch Center are located there. The intermediate unit is glazed, higher and elongated and separates the main entrance to the building and the common areas for relax of the staff.

Office space requirements will satisfy the required number of personnel. There will also be a kitchenette to cater for basic employee requirements, such as self serve light meal and coffee preparation.

10.1.3 Building with Workshops

The building consists of three workshops, store house, space for employees in cathodic protection and I & C (instrumentation and controls) and accommodation and sanitary facilities for 10 people.

- Tools workshop
- Mechanical workshop
- Cathodic protection workshop with a store house

The building construction is mixed - reinforced concrete columns with metal roof supporting structure. Partition walls are non-supporting brick or plasterboard walls.

10.1.4 Store house

The store house is a wide-area volume with 16 m spans. There will be stored pipes and other small items and elements of the gas pipeline network, as they will be placed on the ground directly.
The building construction is mixed - reinforced concrete columns with metal roof supporting structure. Partition walls are non-supporting brick or plasterboard walls.

10.1.5 Checkpoint

The checkpoint is a building for the security of the complex. It consists of surveillance room and bathroom. Due to the specifics of the building, it is directed to the main entrance of the center and is glazed on three sides for better visibility and risk assessment. The surveillance room is equipped with the necessary equipment for access control and has direct telecommunications contact with the office building.

10.1.6 Shed

The shed is designed to provide an open, but covered storage area for large pipes. They will be of a length of 12 m and diameter 32`. The pipes will be stored one above the other, on a chess principle, over the wagons. The maximum designed height is up to 3 rows (levels) of pipes.

10.2 Building Utilities

10.2.1 Mechanical

The following mechanical utilities will be provided:

- Water supply system,
- Sewage System
- Fire Fighting System
- HVAC System

The building mechanical utilities shall be controlled and centrally monitored through a Building Management System (BMS).

10.2.2 Electrical

The following electrical utilities will be provided:

- Electrical Medium Voltage/Low Voltage substation and emergency diesel generator
- Power installation (including distribution boards, UPS)
- Indoor and outdoor lighting systems
- Earthing system
- Lightning protection
- Telephone and data system
- Fire alarm system
- Security / intrusion alarm and Closed Circuit Television (CCTV) system

11. Future Compressor Station

Future expansion of pipeline capacity up to a maximum capacity of 5 bNcmy will require the installation of a compressor.

A compressor station study has been determined the following parameters:

- Estimated compressor duty
- Estimated plot size for compressor station
- Optimum position on pipeline

12. Vessels

12.1 General

Pressure vessels shall be designed in accordance with PED 97/23/EC, the EN 13445 series and project specifications.

Vessel nozzles shall be NPS ≥ 2". Raised face welding neck flanges shall be used. Gaskets containing asbestos shall not be used.

Carbon steel vessels having contact with water shall have a corrosion allowance of 1.5 mm.

12.2 Pig Traps

Pig traps shall be considered as pressure vessels and shall meet the pressure vessel requirements described above.

The material of construction of pig traps shall meet the design requirements for pressure vessels.

The associated piping, valves and equipment shall be suitable for launching and receiving of intelligent pigs, cleaning pigs, and gauging pigs.

12.3 Valves

The location and position of valves shall take into account access for installation, operation and maintenance.

Ball valves shall be utilised for general isolation duties. Plug or globe valves shall be used where throttling service is required.

Ball valves NPS ≥ 4" shall be full bore where required, trunnion type, gas tight, double block and bleed, equipped with hand-wheels and reduction gearing.

Ball valves direct buried shall be of fully welded body design.

All valves in gas service shall be fire safe.

Valves of NPS ≥ 6" shall be equipped with hand-wheels and reduction gearing.

Manual valves shall be fitted with lever wrenches or hand-wheel operators.

Actuated valves shall be equipped with hand-wheels and gearing for manual operation.

For valves NPS ≥ 6" provision shall be made for future replacement of gear operator with pneumatic actuator.

Where appropriate for pressure equalisation before opening block or isolation valves NPS ≥ 6" shall be equipped with by-pass.

Lifting lugs (lifting eyes, lifting devices) shall be provided for valves NPS ≥ 6".

Valves NPS ≥ 4" shall be installed with locking device.

Valves NPS ≥ 2" shall have position indicator.

13. Instrumentation, Control, Security and Telecommunications

13.1 General Requirements

13.1.1 Instrument Design Principles

Analogue instruments shall be used instead of field switch functions, e.g. pressure transmitters shall be used in preference to pressure switches.

Where local indicators are required, local indicators and transmitters shall be combined. Separate local gauges may only be installed if necessary for local operation if process control is not functional.

Full functional independence between control and safety devices shall be assured, including vessel/pipeline connections, e.g. common pressure tap for control and safety devices shall not be used. Instrument redundancies will be considered to ensure adequate system availability, reliability and safety.

13.1.2 Hazardous (Classified) Area Requirements

The area classification for electrical apparatus shall be as shown on the hazardous area classification drawings.

The preferred methods of protection, in order of precedence, are:

Zone 1

EEx 'ia' - Intrinsically safe (class A)
EEx 'e' - Increased safety
EEx 'd' - Flameproof

Zone 2

As Zone 1 or
Ex 'ic' - Intrinsically Safe

All equipment to be installed in explosion-hazardous area shall be designed for operation in dangerous explosive mixtures II A or B class of the T3 (200°C) mixture group.

13.1.3 Ingress Protection (IP) Requirements

The minimum level of ingress protection shall be IP 42 (inside buildings) and IP 65 (outdoors) in accordance with EN 60529 'Classification for degrees of protection provided by enclosures' (IP rating).

13.1.4 Electrical Power Supplies

For critical communications, control and safety related systems power shall be supplied from a fully redundant UPS for up to 12 hours for BV and GMS Komotini and 4 hours for GMS Stara Zagora, AGRS Dimitrovgrad, AGRS Kardjali and Dispaching center(OM Base).

13.1.5 Automation Philosophy

The following philosophy shall be implemented for the automation of the system:

- The process shall be controlled and monitored by PCS (control and high high or low low level shut down/trip).
- Instrumentation for the ESD system is used exclusively for the ESD system.
- Temperature and pressure monitoring for critical sections shall be controlled via 2oo3 voting.
- All inputs (e.g. sub systems or instruments) and outputs (e.g. actuators) as far as reasonably possible should be hard wired.

13.2 Pipeline Operating Philosophy

13.2.1 Normal Operations

The IGB Pipeline System will be monitored, operated and controlled from a new dedicated O&M Base which will be manned 24 hours per day, 365 days per year.

Facilities for the repeat data signals to and from existing SCADA systems on the existing Bulgarian and Greek gas transmission systems have been identified.

The SCADA system shall consolidate real time pipeline status information, providing the operator with an overview of the pipeline status and the facility to transmit remote control commands to metering stations and block valve sites. The SCADA based operation shall be supplemented by voice, fax, email, CCTV and other communications.

Application software shall provide the following software modules:

- Pipeline Model
- Real-Time Model (RTM)
- Look-Ahead Model
- Predictive Model
- Leak Detection and Location Module
- Load Forecaster
- Survival Time Calculation
- Gas Composition Tracking
- Pipeline Trainer

- Off-Line Engineering Studies
- Gas Contract Monitoring

13.2.2 Shutdown Operations

There is no provision for an automatic emergency shutdown to shut all Block Valves on the pipeline or to automatically vent sections of the pipeline. Such facilities are no longer common practice, do not necessarily increase safety levels, and may lead to decreased pipeline reliability.

If there is an incident (mechanical damage, leak, explosion, etc.) on the pipeline, Block Valves shall be closed individually by the operator via the SCADA system thereby isolating sections of the pipeline in accordance with approved emergency procedures.

13.2.3 Field Instrumentation

Field instrumentation shall be certified and installed for the appropriate hazardous classification in accordance with EN 60079. All field equipment shall be suitable for the environmental conditions, and have the appropriate enclosure ingress protection rating as per Section 13.1.3 above.

All instruments installed in process areas shall be minimum ATEX zone 1 regardless of the defined zone, with EEXi instruments preferred.

13.2.4 Metering and Regulating Station Operations

Metering and Regulating Stations shall be designed for remote operation and will be unmanned during normal operation.

13.2.5 Block Valve Operations

Block valves shall be located along the pipeline for isolation and maintenance purposes. In order to preserve the operational integrity of the pipeline system the Block Valves shall not automatically close on suspected pipeline leak/rupture due to detected high flow or pressure drop. In normal operation the Block Valves will always be in the fully open position.

Block valves can be closed remotely from the O&M Base, if required.

13.2.6 Pigging Station Operations

The operation of the Pigging Stations during pigging will be a local manual operation subject to the required pipeline flow conditions being provided by the O&M Base.

13.3 Communication Buildings

13.3.1 Remote Control and Communication Building / Station Control House

At each metering and automated gas regulating station, there will be a Station Control House. The Control House shall house the Station Control System, communication equipment, security panel and Fire & Gas panel etc.

At each Block Valve station will be a Remote Control and Communications (RCC) building. The RCC building shall house the RTU, communication equipment, security panel and Fire & Gas panel etc.

Refer to Section 8.4 for building civil requirements.

13.4 Back-up Communications System

To ensure the integrity of the Fibre Optic Communications backbone, the network shall have a single ring configuration, in order to provide multiple communication paths between the various stations.

Fibre Optic Cable will be used to connect the O&M Base with the Greek and Bulgarian National Gas Transmission Operators.

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13.5 Telecommunications

13.5.1 Fibre Optic Cable Communications Backbone

The communications backbone will consist of a 96-fibre single-mode G.655 Fibre Optic Cable installed along the pipeline from Komotini to Stara Zagora. The backbone will be pure IP based, operating at 10Gbps. Details will be reviewed and confirmed during the course of the Project.
The FOC will be laid in the same trench of gas pipe in Greece and for Bulgarian territory are provided two optical cables : main cable is at a distance of 7 m on the right side of the gas pipeline axis (in a separate trench) and backup cable laid in the same trench of gas pipe.

13.5.2 Network Management System

A single, integrated Network Management System (NMS) for the Ethernet network and all interfacing services shall be provided. The NMS system shall be an exclusive management system for the transmission equipment and transmission signals.

13.5.3 IP PBX Telephone system

A new IP PBX will be provided at the O&M Base station supporting the IP telephone sets of the IGB stations.

13.6 Security

The strategic nature of the IGB Pipeline System necessitates secured stations.

At each Metering, Automated Gas Regulating and Block Valve Station the 'core' installation will be contained within an inner High Security fence. The fence will be monitored by perimeter CCTV and by a fence-mounted Perimeter Intrusion Detection System. LED lighting and /or Infra-red lighting will provide all-weather illumination to support camera observation. The total plot area at each site will be surrounded by a chain-link fence serving to delineate the site boundary and to create a 'dead zone' serving to minimise intrusion by animals and pedestrians but without attempting to create a secure area.

Security CCTV cameras monitoring perimeter fences, gates and doors will provide images for display on the monitors at Security Workstations at the O&M Base. CCTV monitoring will be provided within the inner High Security fence at each site (e.g. Pipeline plant, process equipment, buildings, etc.).

Appendix A Units of Measurement

Base Units

Quantity	Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

Derived Units

Quantity	Unit	Symbol
Frequency	hertz	Hz
Force	newton	N
Stress	newton/millimeter^2	N/mm^2
	kilo newton/metre^2	kN/m^2
Energy, work and heat quantity	joule	J
Power / heat flow	watt	W
Electric charge	coulomb	C
Electric potential EMF	volt	V
Electric resistance	ohm	Ω
Electric conductance	siemens	S

Electric capacitance	farad	F
Magnetic flux intensity	tesla	T
Luminous flux	lumen	lm
Dynamic viscosity	centipoise	cP
Kinematic viscosity	metre^2/second	m^2/s
Area	millimetre^2 (metre^2)	mm^2 (m^2)
Volume	cubic meter	m^3
Velocity	metre/second	m/s

Non SI Units

Quantity	**Unit**	**Symbol**
Time	minute / hour / day	mn / h / d
Temperature	fahrenheit	°F
Temperature	celsius	°C
Volume	litre	l
Mass	tonne	t
Pressure	bar absolute	bara
Pressure	bar gauge	barg
Pipe size	inch	"

Appendix B Pipeline Design Factors

Bulgarian Section

Location Class	Design Factors for Pipeline and Crossings – Bulgaria (Note 1)							
	Pipeline	Crossings						AGI Piping (Note 3)
		With Casing	Without Casing		Railways (Note 2)	Swamps, Rivers, Streams and Overhead HV Power Lines (>110kV) (Note 6)	HDD Crossings (Note 5)	
		Existing or Future Highways (Motorways), and National Roads Class I, II and III	Local / Municipal Roads	Other Roads including Private Roads and Dirt Tracks				
1	0.72	0.6	0.5	0.72	0.6	0.6	0.5	0.5
2	0.6	0.6	0.5	0.5	0.6	0.6	0.5	0.5
3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
4 and Active Seismic Faults (Notes 4, 5)	0.4	0.4						

Notes

(1) This table has been developed in accordance with the requirements of ORDINANCE for safe operation of the device and transmission and distribution pipelines and facilities, installations and equipment for natural gas(under article 200, paragraph 1 of the Energy Law).
(2) In accordance with Bulgarian Ordinances, all railway crossings should be cased.
(3) At AGIs a maximum design factor of 0.6 shall apply to the buried pipeline a minimum of 10m upstream and downstream of the AGI.
(4) The design factor shall extend 200m either side of the active fault line.
(5) Neither ordinances, nor international codes offer guidance for HDDs and active faults. Current DF has been used in accordance with industry norm.
(6) For overhead HV powerlines, the tabulated design factor shall be applied for a distance of 50m either side of the outer conductors.

Greek Section

Location Class	Design Factors for Pipeline and Crossings – Greece (Note 1)										
	Pipeline	Crossings								AGI Piping	Near Concentrations of People in Location Classes 1 or 2 (Note 3)
		With Casing		Without Casing			Railways (Note 2)	Swamps, Rivers and Streams	HDD Crossings (Note 5)		
		Existing or Future Highways and Sealed Public Roads	Private and Unsealed Roads	Existing or Future Highways and Sealed Public Roads	Private Roads	Unsealed Roads					
1	0.72	0.6	0.72	0.6	0.72	0.6	0.6	0.6	0.4	0.5	0.5
2	0.6	0.5	0.6	0.5	0.5	0.5 (width ≥ 4m) 0.6 (width < 4m)	0.5	0.6	0.4	0.5	0.5
3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	N/A
4 and Active Seismic Faults (Note 4, 5)	0.4	0.4									

Notes
(1) This table has been developed in accordance with the requirements of EN 1594 and ASME B31.8. Where more stringent, Greek Regulations have been applied.
(2) In accordance with Greek requirements, all railway crossings should be cased.
(3) This requirement is from ASME B31.8 Clause 840.3. "Concentrations of people" are frequent gatherings of 20 or more people. Locations where this requirement applies may include churches, schools, multiple dwellings, hospitals or recreational areas.
(4) The design factor shall extend 200m either side of the active fault line.
(5)Codes do not offer guidance for HDDs and active faults. 0.4 has been used in accordance with industry norm.