ASSESSMENT, REINSTATEMENT AND MONITORING OF THE STRUCTURAL INTEGRITY OF PUBLIC LIGHTING POLES

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INTRODUCTION

Public lighting poles are subject to corrosion phenomena which, if not monitored, can even lead to their sudden collapse. In order to cope with this problem, Public Administrators are required to evaluate and monitor the integrity conditions of such metallic poles by consulting third party specialized Companies.

Gecop Ltd is working in the field of NDT (Non Destructive Testing) in general and in the last years had the opportunity to develop a complete process, which allows to manage the control on points of light in a scrupulous and scientific way.

A complete procedure has been developed by Gecop Ltd in collaboration with Global Engineering, an Italian company specialised specifically in the checks of degradation status (corrosion, stability, safety, etc.) of steel supports for Public Lighting (PL), with the laboratories of CSM (Centro Sviluppo Materiali) of Castel Romano and with ACEA S.p.A., a multi-utility Company dealing with Water Services (aqueducts, sewers and sewage treatment plants), production and distribution of electricity, Public and Art Lightings.

A joint venture between Gecop and Metalnastri has allowed to develop a complete procedure named **GECOMET SMART CARE SYSTEM – GSCS** (trademark Gecomet).

The **GSCS** System works with complex and flexible algorithms able to assess in real time the structural safety of every kind of lamppost from its parameters (geometry, materials) and environmental data (marine, urban etc.) graphically represented by the MECHANICAL STATE DIAGRAMS (MSD) of the lamppost.

The GSCS experienced procedure is based on the flexible and focused choice of various techniques, according to the typology and environmental features.

The complete procedure of GSCS includes six main modules: GSCS Manager, GSCS Mobile, GSCS Core, GSCS Database, GSCS Maps and GSCS Double-Shield 3.3..

The procedure enables to foresee the remaining lifetime of each tested pole, or the need to further protect it from corrosion by using a specific anticorrosion system, the Double-Layer 3.3. sheets cold applied tape – Metalnastri.

The GSCS procedure also allows to manage testing orders, send assignments and receive data from Operators, provide validation of these data from remote by experienced personnel, receive structural assessments in real time, store Data and produce reports, graphically representing lamp-post position on Google API, distinguish them with different colours according to their condition (verified, to be removed, to be verified) and produce historical records for each lamp-post.

1 – GECOMET SMART CARE SYSTEM

Purpose of this document is to describe the new system created for verifying, monitoring, rehabilitating and for the final testing of Lighting Poles. The present paper covers the two different aspects: verifying and monitoring of the safety/integrity conditions of the Poles, and its subsequent rehabilitation by means of a double-layer coating system named "Double-Shield 3.3.". The system called "***GECOMET SMART CARE SYSTEM*"** consists of the following main applications:

1. GSCS Manager
2. GSCS Mobile
3. GSCS Core
4. GSCS Database
5. GSCS Maps
6. GSCS Double-Shield 3.3.

1.1. – GSCS MANAGER

Is the application residing on the remote server that enables structuring and sending to mobile units (Tablet) in the territory a new set of Poles testing, it also allows the setting of the verification policy updating the Data Base relevant to the types of Pole, update the corrosion/mechanical State Diagram (Mechanical equilibrium diagram), validate by the Verifier the data stored for each post.

1.2. – GSCS MOBILE

This is an ANDROID application that allows the operators to receive through the internet on their Tablets the contract (list of posts with all of their references) to be verified, enter and store data and photos detected during the checks and sent them to a remote server.

1.3. – GSCS CORE

This is the heart of architecture. It resides on remote servers and allows to manage and process the data received by the App on Tablet Mobile Poles. GSCS will save the data on the pertinent database, calculates the mechanical stability of the poles according to a specific algorithm and using the equilibrium CORROSION/MECHANICAL diagram, providing results in real-time to the operator in the field.

1.4. – GSCS DATABASE

The application **GSCS** Database allows to store all the data received from the Tablet after they have been processed by GSCS Core. In addition, the application has a Database register where the Poles subject to a survey are spatially located and then can show them through the GSCS Maps.

1.5. – GSCS MAPS

Is a Web application that uses the Google Maps API to show the position of the supports on the map.

1.6. GSCS DOUBLE-SHIELD 3.3.

GSCS Double-Shield 3.3. consists in applying a corrosion active double layer coating at the base of the Pole support.

2 – SYSTEM DESCRIPTION

GECOMET SMART CARE SYSTEM (GSCS) consists of an integrated software platform that allows the verification of the public lighting supports in the territory. The verification of these Poles must be carried out by certificated operators located throughout and equipped with appropriate measurement equipment and mobile devices (e.g. Tablets) with ANDROID operating system.
The checks to be carried out are assigned to various operators through a Central System. Such Central System will provide the possibility to load an order (which is a set of Poles to be verified, duly structured), to assign the contract or a part of it to one or more operators.
Once the Operators have received the Data from the central system via the internet, the checks on the territory can start. The data collected by the operators are transmitted in real time to a remote Central Server. The operator has the ability to make photos and send them along with the measured data. The data collected by the operators must be validated by a technical expert (engineer) that verifies if the data received are valid or edit and modifies the track received with the help of pictures taken by the operator.
Once the validator has performed his control, he starts a synchronization procedure with the operator who has carried out the verification so that the data can no longer be modified.

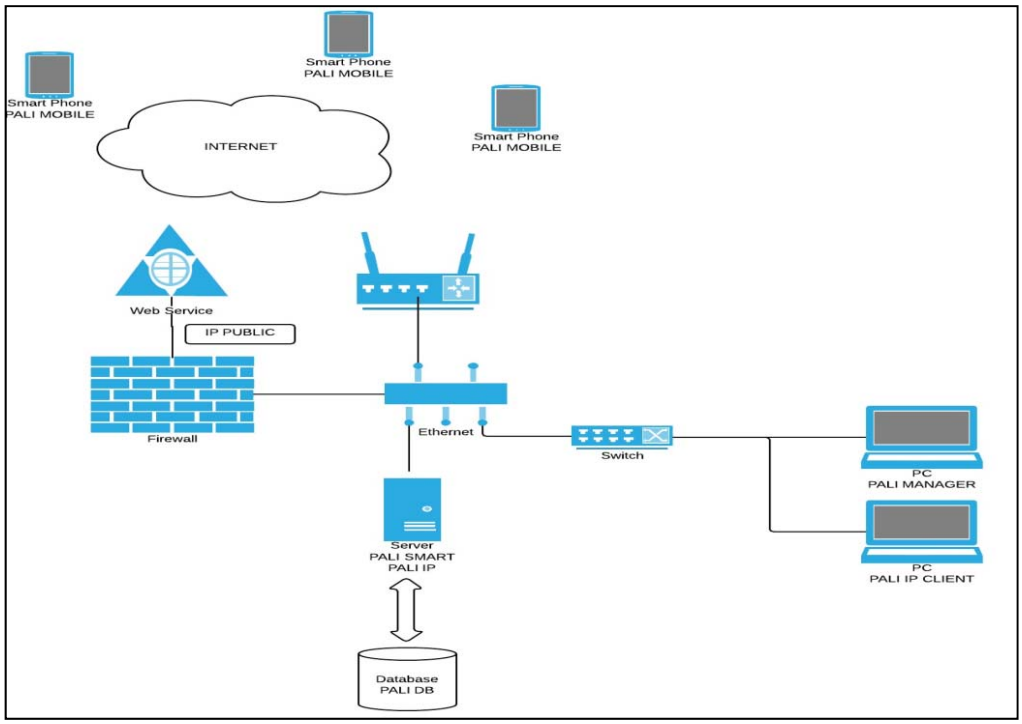

FIG. 1 – SYSTEM OVERVIEW

3 – SOFTWARE ARCHITECTURE

The Software architecture on which the GECOMET SMART CARE SYSTEM is based consists of the following components.

3.1. GSCS MANAGER

It is the software platform that enables the entire tracing and management of public lighting pole through the following features.

• Management of users connected to the system through authentication and profiling;
- job is loaded (a collection of posts subject to verification);
- validation of the order, or making it available to the various machining operations;
- database management relating to various types of post serving the platform for delivering the service, as the lists of armour, support, types of outreaches etc.;
- assign and send to the tablets of the checks to be performed;
- to keep track of all the posts exported about tablets and keeping them in a State "to be controlled" until it is controlled by the operator in the field;
- to maintain the safety of exported and imported data to operators through an authentication system with your username and password;
- generate daily reports with the data collected for each operator
- interfacing with the Internet for data exchange;
- a set of functionality and filtering algorithms that are made available to the technician who is responsible for validating the data collected by operators;
- application for creating Reports and statistics CORE POSTS in various sizes.

The software installed on the remote server calculates the mechanical stability and provides an outcome and/or prescription by using a database of corrosion/mechanical state diagram, developed for the different types of posts to be verified;

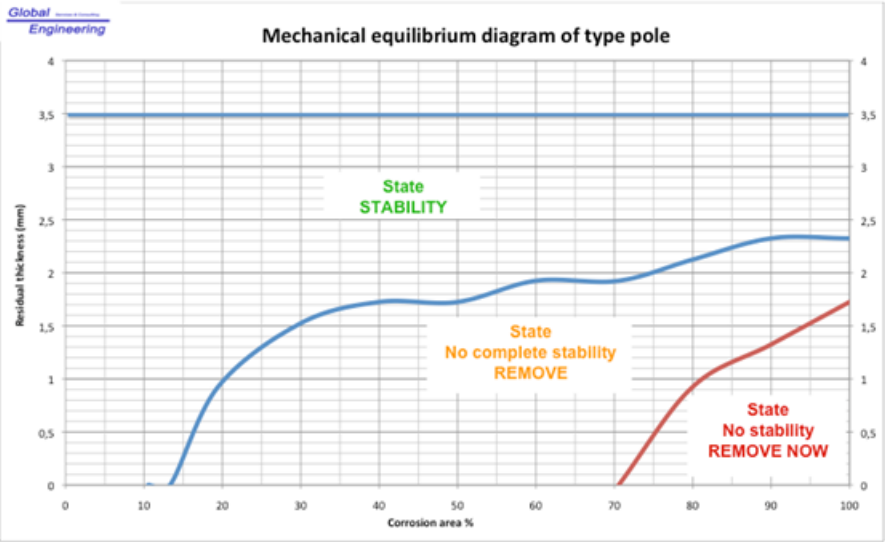

FIG. 2 – CORROSION/MECHANICAL EQUILIBRIUM DIAGRAM

3.2. GSCS MOBILE

Is the ANDROID application that can be installed on Smartphones and Tablets and provided to the operators who perform audits in the field.
The application communicates via the Web Services shown by GSCS Software. The APP installation package consists of an APK that requires permissions on the device to access the file system and the data connection as well as the camera.

FIG. 3 – THE GSCS APPLICATION

On this screen the User ID and the Password of the operator who must carry out the verification are shown.
The application **GSCS MOBILE** communicates with GSCS trough INTERNET.
In case an internet connection is not available, a special feature has been developed that allows to save the data on the local database of the Smartphone/Tablet and then synchronize them with the server database of GSCS.
All this guarantees both continuity of work even if there is no internet connection, and an increased security of data acquired. At the end of the check on the Tablet the following screen will be shown stating the outcome of the survey:

FIG. 4 – THE GSCS APPLICATION

3.3. GSCS DATABASE

Represents the Archive of the System which has been implemented through an *RDBMS*, that is a system for managing relational Databases that enable to manage large amounts of data and to share data between multiple users and applications.

3.4. GSCS MAPS

Is a Web application that uses the Google Maps API to show the position of the supports on the map. Each pole has a GPS coordinate (Table Markers) and each marker can have one or more tracks.

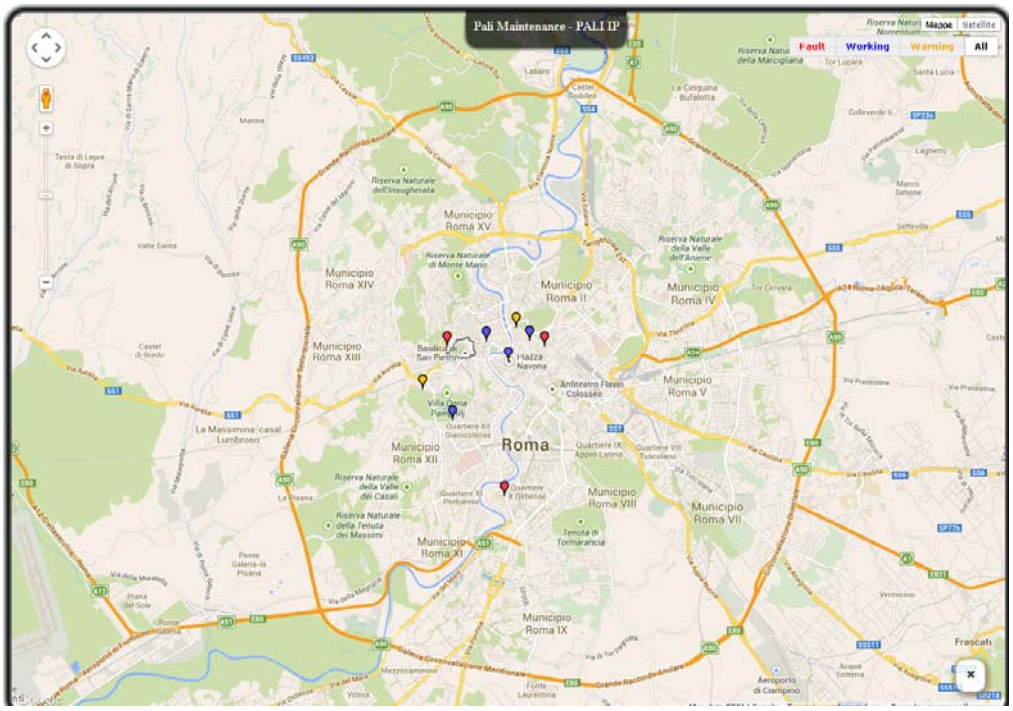

FIG. 5 – MARKERS OF THE POLES IN THE MAP

As it is shown in Fig. 5, the Markers are shown representing the geographical location of the pole. Each Marker has a different colour indicating the status of the post:

Blue Marker = pole that is working smoothly (Working);
Red Marker = pole that is abnormal and needs to be replaced immediately (Fault);
Orange Marker = pole which must be replaced within a defined period of time (Replace).

The software is provided with a filter through which the category of information can be visualized quickly; by clicking on a marker of the Pole, the available information will be displayed for that support:

- POLES ANAGRAPHICAL DATA
- DATA DETECTED

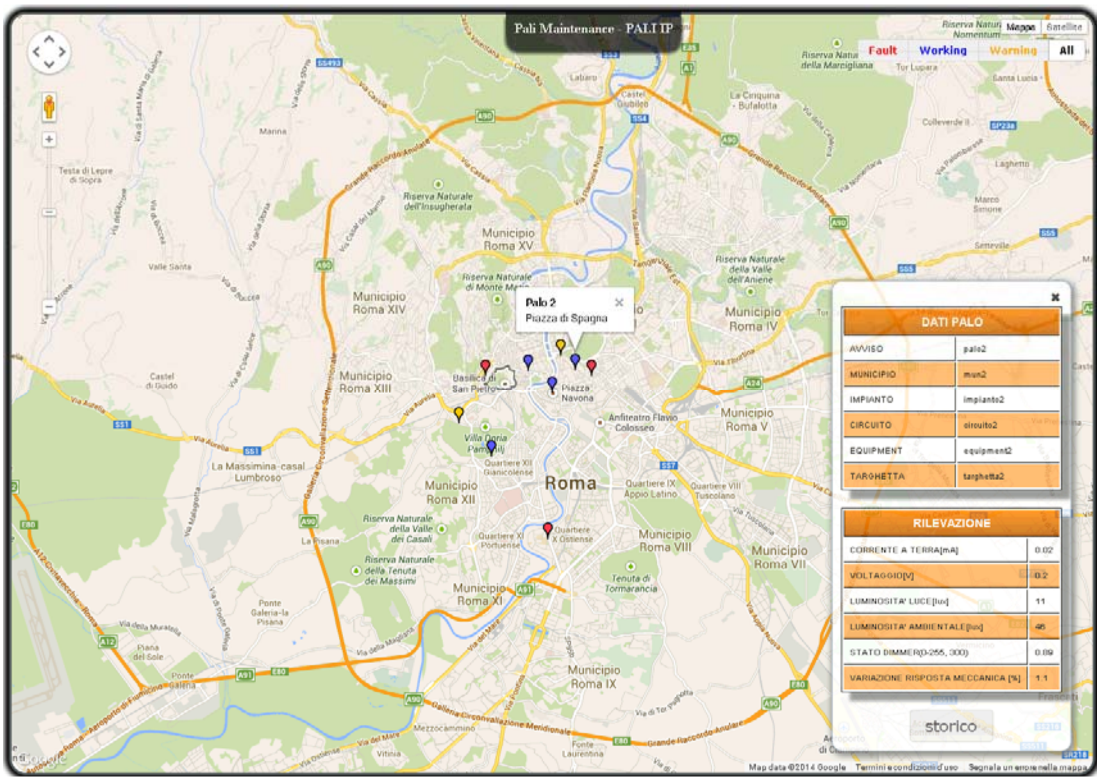

FIG. 6 – MARKERS OF THE POLES IN THE MAP AND DATA RELEVANT TO THE POLE CHOSEN

Also available are the HISTORICAL DATA of the surveys and inspections associated with each single support.

Storico Rilevazioni

CORRENTE A TERRA[mA]	VOLTAGGIO[V]	LUMINOSITA' LUCE[lux]	LUMINOSITA' AMBIENTALE[lux]	STATO DIMMER(0-255, 300)	VARIAZIONE RISPOSTA MECCANICA [%]
0.02	0.2	11	46	0.89	1.1
0.02	0.2	11	46	0.89	1.1
0.02	0.2	11	46	0.89	1.1
0.02	0.2	11	46	0.89	1.1
0.02	0.2	11	46	0.89	1.1
0.02	0.2	11	46	0.89	1.1
0.02	0.2	11	46	0.89	1.1
0.02	0.2	11	46	0.89	1.1
0.02	0.2	11	46	0.89	1.1
0.02	0.2	11	46	0.89	1.1
0.02	0.2	11	46	0.89	1.1

FIG. 7 – HISTORICAL DETAILED DATA RELEVANT TO A SINGLE POLE

4 – SUPPLEMENTARY VERIFICATIONS

In order to fully assess the real corrosion and safety state of Lighting Poles, according to the Italian Standard UNI/TS 11479, a Technical Specification named “Investigation techniques on the conservation status of steel poles for public lighting”, further verification can or should be carried out to verify the corrosion conditions of a Public Lighting Poles.

Some of these investigation techniques which commonly used by GECOMET are the ones shown in the following Figures: The Electrochemical Methodology or the Guided Wave Techniques.

FIG. 8 – Electrochemical Tests on a corroded Pole

FIG. 9 – Guided Waves Test in progress

5 – DOUBLE-SHIELD 3.3. – THE ACTIVE/PASSIVE PROTECTION

FIG. 10 – DOUBLE-SHIELD 3.3.

The corrosion concerning the public lampposts is still a persistent problem all over the world, especially for citizen's safety. In fact, some tragic events have demonstrated that the danger of collapse is often unpredictable, this because there are some cases of internal corrosion that can cause the lampposts plunk down, even if there are no shown evidences.
In the next years, this danger will grow dangerously both for the lack of maintenance and the natural ageing of the metal lampposts.
The company "Metalnastri S.r.l." has developed a new concept of technology based on a double active-passive protection barrier. The Double-Shield 3.3. is a new product that is a compound between two different layers of material: a sacrificial anode as inner layer and a sealing membrane as outer layer. The result is a unique and effective product that provides active protection to the metal surface that has to be covered with, and a physical-chemical passive protection. Double-Shield 3.3. is a free solvent and environmentally friendly and safe.
It is designed to protect permanently underground structures, providing protection for the life-span of the same and virtually avoiding any future maintenance.

5.1. DESCRIPTION

The product "Double-Shield 3.3" is a coupling between an electro-conductive adhesive laminar zinc tape with the main purpose of active protection, and a self-adhesive membrane made from a polymer-modified bitumen with a HDPE carrier foil that performs as external sealing, working as a barrier for physical and chemical protection.

5.2. FEATURES

Active protection: is provided by the sacrificial action of the high purity laminated zinc (>99.95%) by its electro-conductive adhesive which ensures a positive electric connections between the metal substrate and the zinc so that it can act as a sacrificial galvanic anode.

Passive protection: is given by the top coat bonded to the zinc foil, this is composed of a membrane made from a polymer-modified bitumen with HDPE carrier foil which bonds in an

excellent way to the zinc, sealing and protecting it against any external attack and any mechanical damages.

Chemical protection: the special composition of the outer coat provides a resistance to all the aggressive substances that naturally occur in soils.

5.3. MAIN APPLICATIONS

"Double-Shield 3.3" is mainly used for:
- underground pipes;
- steel poles for the public lighting;
- underground steel storage tanks;
- joining under-ground and above-ground steel structures

5.4. ACTIVE PROTECTION

An anticorrosion protection by means of insulating coating (paintings, plastics, rubber and so on) achieves exclusively a passive protection of the surface.
Double-Shield 3.3 coating with electro-conductive adhesive, manufactured by Metalnastri, represents an effective step ahead in the technique of protection against spontaneous corrosion phenomena of whichever metal structure.
The Double-Shield 3.3. inner layer ensures a positive electrical connection between the metal substrate and the zinc , through the specially formulated electro-conductive adhesive.
The high dissolution tension of zinc tape and its fixing to the steel surface by means of binder in the electro-conductive film permits, whenever in some areas there is a lack of coating or whenever an electrolyte infiltrates between the metal structures and the zinc tape, the immediate formation of a galvanic cell, in which, the zinc becomes an anode dissolving itself and protecting the metal structure (cell cathode). In this case the product realizes an "active protection" of the metal surface.
The complete homogeneity and isotropy of the zinc lamina avoid, all along the superficial development, the presence of variations of dissolution tension: it has a very low auto-corrosion consumption.

5.5. PASSIVE PROTECTION – TECHNICAL DATA

Double-Shield 3.3.'s outer layer is a self-adhesive bituminous sealing membrane cold-applied, that is a self-adhesive, flexible, crack-bridging made from polymer-modified bitumen with HDPE carrier foil on one side. It is used for underground structures permanently against ground moisture (capillary water, retained water) non-accumulating seepage water.
The self-adhesive bituminous sealing membrane with HDPE carrier foil affords immediate resistance to water and driving rain, is flexible, tear-resistant and cold-bending. It is environmentally friendly and is resistant to all aggressive substances that occur in soils.
It does not contaminate ground water.

TABLE 1 – DOUBLE-SHIELD 3.3. – MAIN CHARACTERISTICS

Composition	**Weight**	**Width**
	gr/m2	micron
Membrane	1000	1000
Zinc foil	560	80
Adhesive	500	Min. 225
Paper	90	75
TOTAL Zinc and Membrane	**2150**	**1380**
TOTAL Zinc	**700**	**80**
TOTAL Membrane	**1590**	**1290**

Property

Membrane	**Measuring Unit**	**Value**
Weight	Kg/ m2	1.1
Width membrane	mm	1.0
Adhesive thickness	µ	200
Application temperature	°C	+ 3°
	Condition	
Rain resistance		Immediate
Heat resistance	DIN EN 1296,DIN EN 1298	Shape stability
	≥ +70°C storage period 12 weeks	
Cold-bending test	DIN EN 1109	No cracks at 5°C
Water permeability	DIN EN 1928, procedure B	Non-permeable
	Water pressure 4 bar, 24 h.	
Water-vapour permeability	DIN 1931, procedure B	SD= 320m, µ= 2744000
Ultimate tensile strength	DIN EN 12311-2, procedure A	Longitudinal ≥ 90//50mm
		Transvers ≥ 70//50mm
Extension at ultimate tensile strength	DIN EN 12311-2, procedure A	Longitudinal ≥ 900 %
		Transvers ≥ 700 %
Tear resistance test	EN 12310-1	Longitudinal 125 N
		Transvers 65 N
Colour		Black

Laminate Zinc	**Measuring Unit**	**Value**
Thickness	mm	0,080 (-0,005/+0,020)
Purity	%	> 99,95

Adhesive	**Measuring Unit**	**Value**
Thickness	mm	> 0,025
Adhesive on steel		
48 h after application	N/mm	> 0,65
Adhesion zinc to membrane	N/mm	> 0,8
Shear resistance	Hours	> 8
Electrical conductivity	Ohm·mm2	≤ 10
Minimum temperature for application	°C	+ 3°
Working temperature	°C	–10 a +70
Maximum temperature for short period (1/2 hours)	°C	+100

Paper	**Measuring Unit**	**Value**
Weight	Gr/m2	90 ± 5%
Thickness	mm	77 ± 5