OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

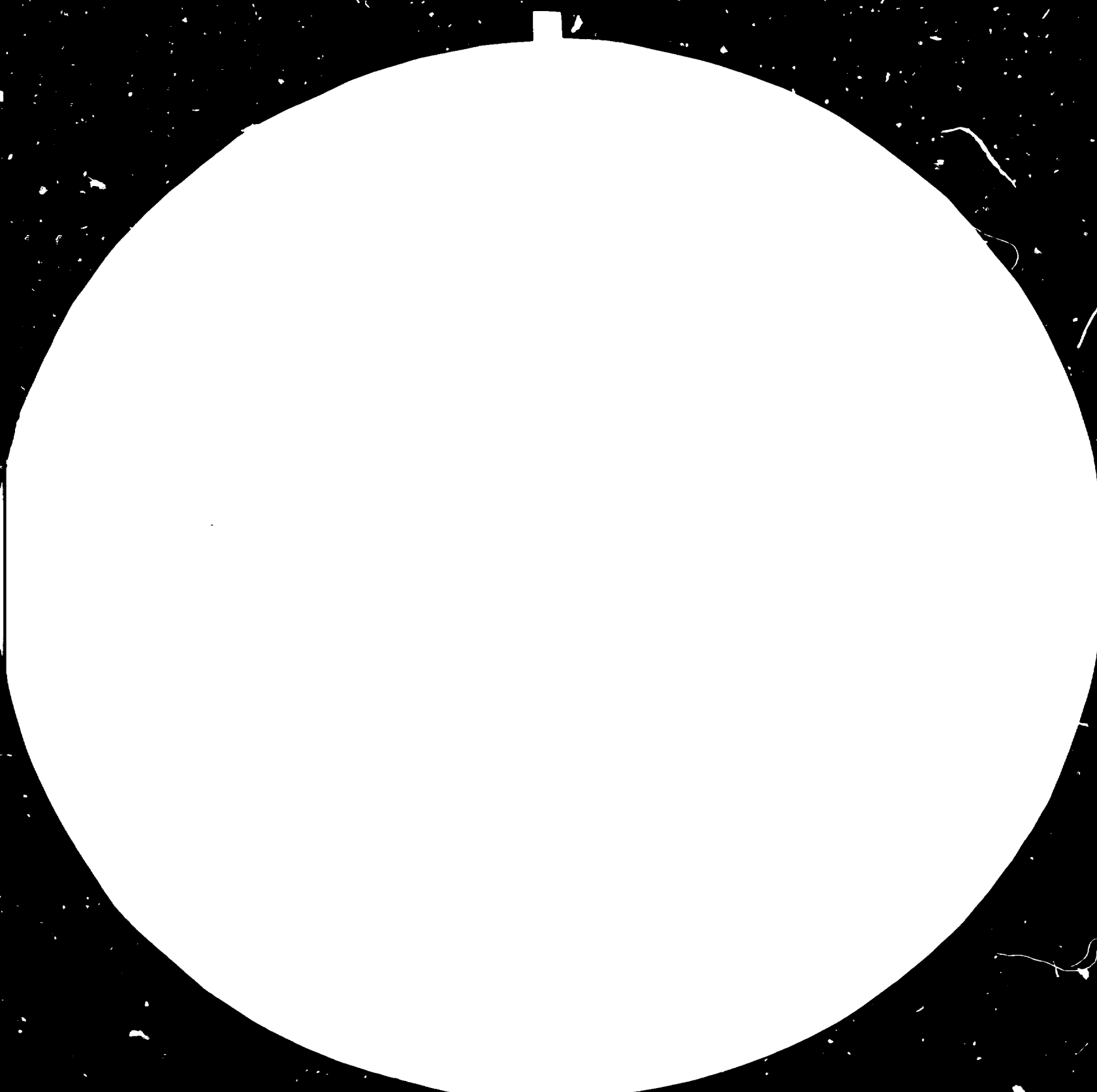
FAIR USE POLICY

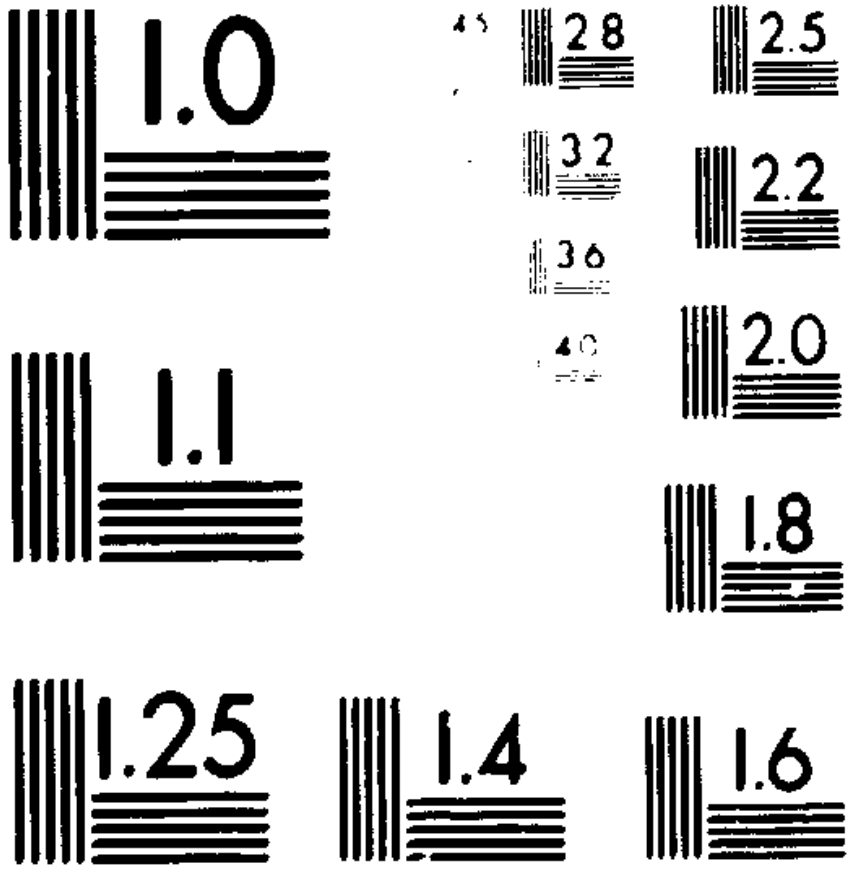
CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org





14082

UNIDO - Czechoslovakia Joint Programme
for International Co-operation in the Field of Ceramics,
Building Materials and Non-metallic Minerals Based Industries
Pilsen, Czechoslovakia

Distr.
LIMITED

JP/81/81
May, 1981

ORIGINAL: English

TESTING INSTITUTE AND PLANT LABORATORIES FOR TESTING NON METALLIC RAW MATERIALS AND PRODUCTS

Preliminary Projects for the Establishment of Testing Laboratories on Central and Plant Levels

By: Miroslav Bareš+
Jan Dřevo
Bořivoj Hatúk+

1981

Special Consultant: Z. A. Engelthaler

+ Research Institute for Ceramics, Refractories and Raw Materials, Pilsen, Czechoslovakia

ABSTRACT

A series of preliminary projects for the establishment of testing laboratories for non-metallic raw materials and products is submitted.

On central level, the project of the Testing Institute for Non-metallic Raw Materials and Products comprises the section of analytical chemistry, physical chemistry and mineralogy, the technological section and the semi-industrial section. They are subdivided into relevant laboratories and pilot plants.

On plant level, three projects of plant laboratories are presented. They are oriented to a kaolin washing plant, a plant producing ceramic products and a plant for the manufacture of refractories respectively.

The projects contain lists of testing equipment, describe work organization and involve some supplementary useful data.

C O N T E N T S

INTRODUCTION

A preliminary project of a Testing Institute for Non-metallic Raw Materials and Products of central or regional character is presented. The always increasing demand for building materials in developing and the least developed countries calls for the exploitation of local non-metallic raw materials in the manufacture of such products as red bricks, lime, cement, heavy clay products, ceramic wall tiles and floor tiles, ceramic sewer pipes, refractories, etc. The establishment of these industries requires geological prospection of non-metallic raw materials and testing of the found deposits oriented to their applicability for the industrial processing. The establishment of a local testing institute represents the creation of a scientific basis assessing continuously the taken samples of raw materials during prospection. The obtained results permit to control the prospection work effectively and serve to the planning of industrial development. The testing institute is also a prerequisite for a purposeful industry oriented functioning of local Geological Survey in the field of non-metallic raw materials. Besides, it is expected to assist established plants in the preparation of body composition for their products, to carry out more sophisticated tests of their raw materials, semi-products and finished products, and to serve as basis for local training.

The investment cost of a testing institute should be compensated by saving the costs which would otherwise incur for tests carried out abroad.

The preliminary project of a Testing Institute for Non-metallic Raw Materials and Products is demonstrated on clays, kaolins, sands, limestones and bentonites /raw materials/ and on ceramics, refractories and cement /products/. The application of the project to other non-metallic products is easily feasible.

Further projects are preliminary projects of laboratories installed in the production plants - a kaolin washing plant, a plant for the manufacture of ceramic products and a plant for the manufacture of refractories. Plant laboratories are indispensable parts of factories. Their tests bring important indications for quality control - an important method of production management.

+/

TESTING INSTITUTE

FOR NON-METALLIC RAW MATERIALS AND PRODUCTS

TESTING INSTITUTE

FOR NON-METALLIC RAW MATERIALS AND PRODUCTS

A

SECTION OF ANALYTICAL CHEMISTRY,
PHYSICAL CHEMISTRY AND MINERALOGY

I.

Laboratory for Reception, Registration and Preparation of Samples

1.1 Assignments of the laboratory for reception, registration and preparation of samples

The laboratory receives samples of extracted raw materials and beneficiated raw materials, designates them by numbers, makes records and files them. Samples with detailed specification of analyses and tests to be carried out are passed to preparation and sorting. Here they are dried, grain size reduced, quartered, sorted, screened and dewatered. If need be heavy portions are separated.

The required quantities of samples as prescribed by testing standards are passed on to be subjected to physical-chemical, mineralogical and technological tests and to be prepared as analytical samples. The laboratory determines also the washed product of plastic raw materials and carries out sieve analyses of sands.

The laboratory receives also the samples of products and semi-products in the field of non-metallic minerals based products for registration. Registered samples are passed on to relevant laboratories for sample preparation and testing.

1.2 A note to the methodology of non-metallic sample preparation

The laboratory is expected to furnish information on composition and properties of raw materials and of important portions of raw materials.

The objective of the preparation of samples to be subjected to tests and analyses is to provide rapidly representative samples for chemical, physical and mineralogical analyses as well as for technological tests. It is necessary for the original sample to be delivered to the laboratory in sufficient quantity so that trustworthy results may be obtained. The required quantities for preliminary tests range from 5 to 10 kg per sample depending on the sort of raw material. The preliminary tests are physical tests oriented to industrial application. The quantity of a sample for laboratory tests ranges from 50 to 100 kg, for various raw materials. Laboratory tests comprise repeated preliminary tests, analytical and mineralogical tests.

The preparation of a sample for analysis is from the view of handling a rather complicated matter involving grain size reduction (crushing, grinding), manifold mixing and quartation, crushing, rubbing and screening. A special care must be taken during these operations to avoid contamination of samples (e.g. by abrasive wear of grinding equipment). It is, therefore, necessary to use suitable machines in a modern laboratory.

The separation of technologically important portions of raw materials means the extraction of defined grain size portions (e.g. grain size fractions of sands or kaolin, slurry and sand portions in raw kaolins). This work, if done manually, is long lasting and can be influenced by personal errors. Suitable

machines should, therefore, be selected for this phase, too.

A proposal for the laboratory equipment and its arrangement was elaborated in concordance with the above note.

1.3 Work organization in the laboratory for preparation of samples

(Module No. 1, Lab. TI/I)

Samples of raw materials are received in the room (I-A), marked with numbers and registered. Records on received samples are put into files. A sample with a route card of required operations is passed to the room for preparation and sorting. A portion of a sample is subjected to the test of technological humidity (I-B-1). A sample delivered in lumps is dried and then crushed (I-B-3), required part being separated for further operations. The remainder of the sample is returned back to the room (I-A) for storing. Sand samples are weighed (I-C-3). Some materials are sorted on request (I-B-5). The equipment (I-B-7) serves to dewater suspensions. If the separation of heavy components is required, it takes place in this phase (I-B-2). A part of samples is already after this preparation and sorting delivered to particular laboratories for testing. The other part is passed on to further dressing if required into the room (I-C) where the samples are fine ground (I-C-1) and mixed (I-C-2). They proceed afterwards to chemical analysis,

physical measurements and mineralogical analysis.

Samples of non-metallic semi-products and products are only registered and provided by a route card to be prepared and tested in further laboratories.

1.4 Arrangement and equipment of the laboratory for reception, registration and preparation of samples

(Module No. 1, Lab. TI/I)

A Reception, registration and store of samples	Pcs
Furniture:	
Laboratory bench	1
Shelf	3

B Preparation and sorting of samples	
Instruments:	
1 - Electric hot air drier (200 l)	1
2 - Centrifuge for separation of solid phases	1
3 - Laboratory jaw crusher	1
4 - Screening machine for wet and dry screening	1
5 - Sorting machine for separation of grain fractions	1
6 - Rotary vacuum pump with a vacuum vessel (40 dm^3)	1
7 - Bench for vacuum filtration (vacuum distribution, 6 sucking flasks 3000 ml)	1

Furniture:	
Low laboratory bench	2
High laboratory bench	3
Fume cupboard	1

C Preparation of analytical samples

Instruments:	
1 - Laboratory ball mill	1
2 - Laboratory mixer	1
3 - Digital quick balance (160 g, 1000 g)	2
4 - Electric hot air drier (60 l)	1

Furniture:	
High laboratory bench	4
Laboratory cabinet	1

TESTING INSTITUTE

FOR NON-METALLIC RAW MATERIALS AND PRODUCTS

A

SECTION OF ANALYTICAL CHEMISTRY,

PHYSICAL CHEMISTRY AND MINERALOGY

II.

Laboratory for Analytical Chemistry

2.1 Assignments of the laboratory for analytical chemistry

Samples for analyses are prepared in the laboratory for preparation of samples as described in the preceding chapter. The basic task of the analytical chemistry is to analyze continuously non-metallic raw materials, beneficiated raw materials, semi-finished products and final non-metallic products.

The following activities are carried out:

- abridged chemical analyses - determination of
  Al_2O_3 and Fe_2O_3 in clays,
  Al_2O_3, Fe_2O_3, TiO_2 in kaolins,
  Al_2O_3, Fe_2O_3, TiO_2, SiO_2 in sands,

- complete chemical analyses - determination of the following compounds in all non-metallic raw materials and products:
  SiO_2, TiO_2, Al_2O_3, Fe_2O_3, FeO, MgO, CaO, Na_2O, K_2O, H_2O^+, H_2O^-

2.2 A note to the methodology of quantitative chemical analysis of non-metallics

The quantitative chemical analysis of clay, kaolin and sand samples ranges among the most demanding experimental methods in laboratories of non-metallics. The classical chemical analysis of non-metallics involving gravimetric, complexometric,

photocolorimetric and flame photometric procedures is distinguished by precision but it is time consuming. The modern physical-chemical methods of chemical analysis, e.g. the atomic absorption spectrometry, x-ray fluorescent spectrometry and others indicate reliable results, but they are very expensive and require a highly qualified personnel. Therefore, such laboratories are preferred where the classical and modern conceptions of analytical chemistry are efficiently and logically combined with the aim to win promptly precise experimental data for mining and beneficiation of raw materials and their processing into products.

The atomic absorption spectrophotometry is proposed as basic procedure in chemical analyses of clays, kaolins and sands. The application of a progressive decomposition of samples (e.g. by lithium metaborate or by pressure decomposition in acids) and their conversion into liquids permits all main oxides to be determined in aliquot proportions.

It is necessary to apply classical methods, too, namely in cases when the atomic absorption spectrophotometry is not applicable or exact analytical values are desirable.

Determination of	Method
H_2O^+, H_2O^-	gravimetry
SiO_2	gravimetry - from the solution of a sample by alkalic fusion
Al_2O_3	complex titrimetry - in aliquot proportions of titrate
oxides of alkaline earths (MgO, CaO)	complex titrimetry - in aliquot proportions of titrate
Fe_2O_3, TiO_2	photocolorimetry
FeO	manganometric titration from special weighed dose
Na_2O, K_2O	flame photometry from weighed dose after decomposition by acids

The method of atomic absorption spectrophotometry can also indicate promptly and precisely trace elements in leaches of non-metallics for special use (e.g. Cu, Mn, Fe), carry out basic determination in analyses of supply and waste water in solutions after breakdown of sands (e.g. Cr), the determination of toxic element concentration (e.g. Pb, Cd, Zn, Sb, Cu) in all raw materials, products and wastes in connection with protection against air and water pollution.

The submitted project of arrangement and equipment of the analytical laboratory complies with the described conception.

2.3 Work organization in the laboratory for analytical chemistry

(Module 2, Lab. TI/II)

Samples for analyses are received from the laboratory I (Laboratory for preparation of samples). After drying (II-F-4), determination of mass (weighed doses for decomposition, gravimetric determination, etc.) the samples are carried to the balance room (II-B). For the analytical determination proper, the samples are decomposed in fume boards (II-C) by fusion (II-C-1) or by dissolving in acids (II-C-2). The conversion of decomposed samples into solutions takes then place in positions (II-C-3 and II-C-4). The solutions of samples are then passed either to the atomic absorption spectrophotometer (II-D) or to the room for preparative chemistry (II-F). The adjustment of solutions for the atomic absorption (pipetting, correction and others) and for the spectrophotometry proper takes place in the position (II-D-1). Further work with prepared solutions consists mostly of classical analytical procedures: complex titrimetry (II-F-3), spectrophotometry (II-F-1), water analysis (II-F-2). Samples are fired in the kiln (II-F-5). All preparative operations are carried out on the laboratory benches in the room (II-F): pipetting, filling of calibrated vessels, precipitation and other reactions.

In the same room, the distilled water is produced for the needs of all laboratories. Computations, protocols and results are elaborated in the room (II-A) where a calculator is available (II-A-1). There is also a file of samples in this room. Chemicals, laboratory glass and laboratory aids are stored in the room (II-G). A shower bath (II-H) should be erected and first aid equipment provided for the purpose of safety and health protection.

2.4 Arrangement and equipment for the analytical laboratory

(Module No. 2, Lab. TI/II)

A Reception of samples, evaluation of results

Instruments:	Pcs
1 - Table calculator	1
Furniture:	
Low laboratory table	2
Laboratory cabinet for deposition of samples	1
Laboratory cabinet with armoured box for deposition of precious metals and poisons	1

B Balance room

Instruments:	
1 - Analytical semi-automatic balance (100 kg)	2
2 - Digital quick balance (200 g)	1

Furniture:

Low laboratory table	1
Desk inbedded in a wall	1

C Fume_cupboards

Instruments:

1 - Mecker burners	8
2 - Sand bath	2
3 - Water bath	1
4 - Heater (for digestion flask 250, 500 ml)	2

Furniture:

Fume cupboard	2
Low laboratory table	2

D Atomic_absorption_spectrometer

Instruments:

1 - Two-beam spectrophotometer with automatic control of inlet gases incl. hollow cathod lamps	1

E Compressor (necessary accessory)

1 - Compressor	1
2 - Pressure vessels for acetylene and dinitrogen monoxide	2

F Preparative_chemistry

Instruments:

1 - Single-beam spectrophotometer for photocolorimetry, turbidity measurements, photometric and fluorimetric titration	1

2 - pH meter	1
3 - Electromagnetic mixer	1
4 - Electric hot air drier (60 l)	1
5 - Electric kiln (1200°C, 20 cu.dm)	1
6 - Glass distillation apparatus (12 l/hour)	1

Furniture:

High laboratory bench	8
Laboratory sink	2
Low laboratory bench	2
Laboratory cabinet for chemicals and glass	4

G Store room

Furniture:

Shelf	4

H Shower bath 1

TESTING INSTITUTE

FOR NON-METALLIC RAW MATERIALS AND PRODUCTS

A

SECTION OF ANALYTICAL CHEMISTRY,

PHYSICAL CHEMISTRY AND MINERALOGY

III.

Laboratory for Physical Chemistry,

and Mineralogy

3.1 Assignments of the laboratory for physical chemistry and mineralogy

The laboratory evaluates non-metallic raw materials and beneficiated raw materials by suitable methods. It participates also in testing of industrial ceramics.

Clays are subjected to grain size analysis and test of whiteness or colorific power. Mineralogical analysis is determined by combining testing results with computations from chemical analysis. Specific properties such as adscrption capacity, specific surface and others are determined by physical-chemical methods.

Raw and washed kaolins also undergo grain size analysis (results should be expressed by statistical parameters from cumulative grain size curve) and their whiteness is measured. Their colour shade is evaluated, pH value and further physical-chemical and physical parameters determined. The mineralogical composition of selected raw materials is determined taking into consideration the results of thermal analyses combined with data of chemical analyses and mineralogical characteristics are elaborated.

Sands containing clay proportion are evaluated in their both fractions. The sand fraction is assessed from the view of morphology and grain colour while the clay fraction is described by its mineralogical characteristics. Due attention is paid to heavy portions of sand samples (mineralogical quantitative and qualitetive analysis of contaminating admixtures).

Other non-metallic raw materials are tested with regard to their required properties in application.

The bulk density of limestone is tested, its mineralogical and petrographical characteristics are investigated by the polarising microscope.

The laboratory for physical chemistry and mineralogy evaluates thin sections of non-metallic products for the technological laboratory and co-operates in other tests if need be.

3.2 A note to the methodology of physical-chemical and mineralogical analyses of non-metallic raw materials

A series of professional publications finds relations between physical-chemical properties and mineralogical composition of clays and kaolins on one side and their technological properties on the other side. Time demanding technological tests and considerable dispersion of obtained data brings along increasing use of exact methods of physical chemistry for non-metallic raw material assessment.

An efficient x-ray sedimentation analyzer with fast output of reproducible results within the range of 0.1 to 100 micron is recommended. A remission photometer is proposed for measuring e.g. whiteness of kaolin and colour shades of clays.

The proposed laboratory could also be extended by further physical-chemical tests (e.g. adsorption determination in basic colours, determination of specific surface, etc.), which if suitably applied, can become important and fast testing processes in determination of technological parameters. It is evident that this part of the laboratory could develop prospectively according to local needs.

Quantitative mineralogical composition of clay samples can be determined only on basis of a set of analytical methods as microscopical analysis, thermal analysis and quantitative chemical analysis. Accordingly a polarizing microscope and an equipment for simultaneous thermal and gravimetric analyses is proposed. Petrographical analyses of other raw materials as e.g. quartz are determined by these methods, too. Chemical analyses for mineralogy are performed by the analytical laboratory.

An important part of the complex sand evaluation are the quantitative and qualitative mineralogical analyses of heavy minerals. The preparative part of this work is done by the Laboratory I, the mineralogical analysis proper is based on microscopical investigation and microchemical analyses.

3.3 Work organization in the laboratory for physical chemistry and mineralogy

(Module 3, Lab. TI/III)

Samples for physical-chemical and mineralogical analyses are delivered by the Laboratory I (Reception,

registration and preparation of samples). The samples are mostly prepared and adjusted by procedures eliminating the influence of physical--chemical determination results. The samples for grain size distribution analysis are dispersed after separation of coarse portions and measured by the Sedigraph (III-A-2). The samples to be measured on whiteness are mixed (I-C-3), pressed into tablets and measured by a remission photometer (III-A-3). Analytical balance (III-A-1) is available for the whole laboratory. Samples for the mineralogical analysis (III-B) are upgraded in the same way as for chemical analyses (e.g. for thermal analyses III-B-3) or fractions are analyzed microscopically (III-B-1) and (III-B-2).

Work organization in physical-chemical measurements is very specific and its description would considerably exceed the extent of this project. The instruments placed in these rooms are, of course, used for routine tests, too (pH, conductivity).

3.4 Arrangement and equipment of the laboratory for physical chemistry and mineralogy

(Module 3, Lab. TI/III)

A Measurements of grain size distribution and whiteness

Instruments:	Pcs
1 - Analytical balance (100 g)	1

2 - X-ray analyzer of grain size distribution (0.1 to 100 microns) with direct record of cumulative grainage curve	1
3 - Two-beam photometer (400 - 700mm) for measuring whiteness and colours of powdered materials	1

Furniture:

Low laboratory bench	2
Desk inbedded in a wall	1
Laboratory cabinet	2

B Workroom of mineralogy

Instruments:

1 - Polarizing microscope for identification of minerals and determination of their optical properties (enlargement 20 to 640 times)	1
2 - Stereoscopic microscope (enlargement 1.7 to 40 times)	1
3 - Thermoanalytical equipment for differential thermal and gravimetric analyses and derivation of the gravimetric curve up to 1500°C	1
4 - Digital quick balance (200 g)	1

Furniture:

Low laboratory bench	4
Laboratory cabinet	1

C Physical-chemical measurements

Instruments:	
1 - pH meter	1
2 - Apparatus for measuring conductivity of solutions and suspensions (0 - 500 mS)	1
3 - Electromagnetic mixer	1
4 - Electric hot air drier (60 l)	1
Furniture:	
Low laboratory bench	6

TESTING INSTITUTE

FOR NON-METALLIC RAW MATERIALS AND PRODUCTS

B

TECHNOLOGICAL SECTION

IV.

Technological Laboratory for Testing

Non-metallic Raw Materials

4.1 Assignments of the technological laboratory for testing non-metallic raw materials

The technological laboratory carries out routine tests of non-metallic raw materials such as clays, kaolins and sands, limestones, quartz, etc. closely with the technological laboratory for testing non-metallic products.

Clays are subjected to the following tests: humidity; basic parameters of grain size distribution (predominantly as sieve residues on sieves 8, 2, 0.09, 0.063 mm) by wet screening; longitudinal changes in drying and firing (as a rule 110, 1250 and 1400°C); water absorption; firing colour, bending strength after drying; binding power; pyrometric cone equivalent; content of water of plasticity; number of plasticity.

Tests of kaolins:
humidity; grain size of sieve residues (on sieves 0.2, 0.09, 0.063 mm) by wet screening; particle content under 2 microns by sedimentation; rheological properties (dynamic viscosity or outflow duration); bending strength after drying; refractoriness and abrasivity.

Sands are tested on humidity and further tests depending on their nature according to agreement between supplier and client (e.g. firing test).

Tests of limestones:
The humidity of quick lime is tested. Limestones applied as fillers for plastics are subjected to

sieve analysis, sedimentation analysis and test of whiteness.

Quartzs undergo sieve analysis and test of refractoriness.

4.2 A note to the methodology of technological tests of non-metallic raw materials

The methods of technological tests of non-metallic raw materials are mostly based on traditional procedures used in processing industries. The procedures of technological tests simulate as a rule the behaviour of non-metallic raw materials in production operations (shaping, drying, firing). The results of tests are compared with parameters of bodies, semi-products and final products of processing industries. Only a limited number of technological tests is based on indirect determination of a certain technological property - in these cases relations between physical--chemical properties of non-metallics and their impacts in technological application are used.

A rational proposal of equipment for technological laboratory engaged with the tests of clays and kaolins, limestones and quartzs and other non-metallic raw materials is represented in the following text and in schematic representation (Module 3, Lab. T I/IV). The proposal recommends instruments and aids, the reliability of which has been verified by the experience of many years.

4.3 Work organization in the technological laboratory for testing non-metallic raw materials

(Module 3, Lab. TI/IV)

The samples for technological tests are conveyed from the Laboratory I (Reception, registration and preparation of samples). The technological laboratory co-operates closely with the laboratory for physical chemistry and the results of the both laboratories form an integral part of protocols on evaluated samples.

A part of samples of plastic raw materials (clays, kaolins) of a grainage under 2 mm, is processed into plastic body of which small shapes and briquettes are formed (IV-A-8), these are dried (IV-A-9) and fired (IV-A-10). Tests of plasticity and determination of water of plasticity are performed in the position (IV-A-6), bending strength in (IV-A-11). The evaluation includes also the drying shrinkage, firing shrinkage, water absorption, etc. A part of samples serves for determination of sieve residues (IV-A-3), abrasivity (IV-A-1) and the representation of kaolin, slip and sand fractions (IV-A-2). All rheological determinations are carried out in the positions (IV-A-4) and IV-A-5). A part of samples is evaluated from the view of granulometry by manual sorting on sieves (IV-A-3), another part is tested for humidity (IV-A-9) and other parameters if need be. All determinations of mass are carried out in the position (IV-A-7), the drying in (IV-A-9) and the firing in (IV-A-11). The test of refractoriness takes place in technological laboratory for testing non-metallic products.

A store for deposition of processed samples, laboratory aids, moulds, auxiliary material, spare parts, etc. is available.

Evaluation of test results, calculations, drafting of protocols on tests incl. data obtained by the laboratory for chemical chemistry are elaborated in the room (III-C).

4.4 Arrangement and equipment of the technological laboratory for testing non-metallic raw materials

(Module 3, Lab. TI/IV)

A Technological testing

Instruments:	Pcs
1 - Apparatus for determination of abrasivity (used for testing kaolin for paper industry)	1
2 - Equipment for wet sorting by sedimentation (it serves for determination of kaolin content in washed suspensions)	1
3 - Experimental equipment for sorting by screens	1
4 - Synchronous electric rotary viscometer	1
5 - Through-flow viscometer	1
6 - Equipment for determination of water and number of plasticity by Pfefferkorn	1

7 - Digital quick balance (1000 g)	1
8 - Equipment for preparation of testing corpuscles	1
9 - Electric hot air drier (200 l)	2
10 - Bending strength tester	1
11 - Laboratory Superkanthal kiln (1600°C)	1
12 - Laboratory mixer	1

Furniture:

High laboratory bench	8
Low laboratory bench	4
Laboratory sink	2
Laboratory cabinet	3

B Store room

Furniture:

Shelf	4

TESTING INSTITUTE

FOR NON-METALLIC RAW MATERIALS AND PRODUCTS

B

TECHNOLOGICAL SECTION

V.

Technological Laboratory for Testing

Non-metallic Products

5.1 Assignment of the technological laboratory for testing non-metallic products

This technological laboratory carries out laboratory tests of body composition for the non-metallic products such as ceramics, refractories and cement and investigates by means of technological tests the properties of semi-products and products.

The body composition for preliminary tests for the manufacture of ceramic building materials, ceramic sanitary and utility ware is prepared in a planet ball drum, laboratory tests of larger quantities in drums of 5 to 7 litre or in a small ball mill. Testing corpuscles or products based on experimental bodies are compacted in a suitable mould by a laboratory press, greater quantities of pressed pieces may be produced by a larger press in the pilot plant (Module 6, Lab. TI/VI). The testing corpuscles for preliminary tests are fired in a gradient kiln, greater quantities of semi-products and products in an electric laboratory kiln. The laboratory tests of body composition for refractories are carried out in a similar way. The laboratory tests of refractory body composition simulate in a simplified way the refractory manufacturing process. Cement is tested after being mixed with fillers and water and moulded into concrete testing corpuscles.

The technological laboratory carries out the following physical-technological determinations in the field of building ceramics, sanitary and utility ware: humidity, grain size distribution and sieve residues of bodies, bending strength (especially for building materials) of pressed pieces, dried pieces, semi-products and products, thermal expansion of fired body and glazes,

correspondence of thermal expansion of body and glaze, glaze resistance to cracking, expansion by body hydration, shape and dimension deviations of products and semi-products, assessment of product appearance.

The verification of sanitary and utility ware manufacture takes place on a larger scale in the technological workshop. The products are shaped by casting into plaster moulds or by turning on a potter's wheel. The manufacture of plaster moulds is also situated in this workshop.

The task of the technological laboratory in the field of refractories is to determine the following properties: humidity, grain size distribution of work bodies, drying and firing shrinkage, physical properties of fired corpuscles or products, compressive strength at ambient temperature, refractoriness of raw materials and products, refractoriness under load, additional linear changes of products, thermal expansion.

The cement tests comprise pressure air testing and laboratory screening of fillers and tests of concrete corpuscles: determination of setting time , autoclave shrinkage determination, hydration heat determination, water absorption, bending strength and compressive strength tests.

5.2 A note to the methodology of experimental body composition and technological tests of non-metallic semi-products and products

The work methods in the technological laboratory are based on the traditional procedures for assessment of

body compositions, semi-products and products and current determination of their physical-mechanical and technological properties in the field of building ceramic materials, ceramic utility and sanitary ware, refractories and cement on one side and on experience in development of testing blends to improve their properties on the other side.

5.3 Work organization in the technological laboratory for testing non-metallic products

(Module 4, Lab. TI/V)

The technological laboratory for testing non-metallic products co-operates closely with the laboratory III (Laboratory for physical chemistry and mineralogy) and the laboratory IV (Technological laboratory for testing raw materials) as some of their equipment applicable for technological tests has sufficient capacity to serve them all.

Raw materials are stored in containers (V-E on the left behind the door). Semi-products and products to be subjected to heat and mechanical-technological tests are stored on shelves in the room for sample preparation (V-A-1). The semi-products and products are cut into required pieces (V-A-1) and prepared as rollers for the determination of compressive strength or refractoriness under load (V-A-2) or corpuscles to be subjected to the test of thermal expansion correspondence of body and glaze (V-A-3). A special preparation is required for the identification of minerals by means of

a polarizing microscope (e.g. in quartzites and silica) (V-A-4) for which microscopic thin sections are produced. The evaluation of these slice sections takes place in the laboratory III (Laboratory for physical chemistry and mineralogy).

The determination of raw material and product refractoriness, refractoriness under load and refractory bending strength is carried out in the heat testing room (V-B) in positions (V-B-1, V-B-2, V-B-3) respectively. Thermal expansion of body and glazes is determined in the same room for ceramic semi-products and products (V-B-4) as well as correspondence of thermal expansion of body and glaze (V-B-5). Additional linear changes of refractory materials are tested in a Superkanthal kiln placed in the technological laboratory for testing non-metallic raw materials (IV-A-11).

Physical properties (V-C-1, 2, 3, 4), deviations in shapes and dimensions of ceramic products and refractories (V-C-5, 6), compressive strength (V-C-7) and bending strength of ceramic products (V-C-8) are tested in the physical-mechanical testing room of the technological laboratory (V-C). Bending strength after pressing and drying of ceramic semi-products and products is determined in the technological laboratory for testing non-metallic raw materials (IV-A-10). Water absorption by the vacuum method is tested by the laboratory I (Reception, registration and preparation of samples - I-B-6).

Preliminary tests of body composition for ceramic materials are executed in the workroom of experimental technology (V-D). The sequence of body preparation is as follows. Weighed raw materials (V-D-1) are proportioned to a planetary drum (V-D-2), the prepared slurry is dewatered by casting onto a biscuit tile or plaster plate and dried in a drier (V-D-3) and pressing body is prepared. Experimental corpuscles are pressed by a hydraulic press (V-C-7) into a suitable mould. The corpuscles are dried (V-D-3) and fired either in a gradient kiln (V-D-4) or an electric kiln (V-D-5). Fired pieces are assessed and glazed and glost fired if need be. If the results are favourable, verification tests are executed on a larger scale in the technological workshop (V-E).

Some operational tests as determination of sieve residues (V-D-7), humidity of bodies and sieve analyses are also carried out in the workroom of experimental technology.

The technological workshop (V-E) verifies the foregoing preliminary tests of composition as said before. The equipment of the workshop consists of a line for dry body preparation applied especially for testing refractory materials and a line for wet body preparation used mainly for ceramic products. The dry line includes raw material drying (V-E-1), crushing (V-E-2), grinding (V-E-3), sorting (V-E-4), weighing (V-E-5,6), mixing (V-E-3) with concurrent wetting. The wet line comprises the phases of raw material weighing (V-E-5), wet grinding (V-E-7,8), dewatering of slurry (V-E-9), drying of body (V-E-1) and

pressing body preparation. Pressed pieces are shaped either by a laboratory hydraulic press or by a press of the pilot plant (VII). Pressed pieces are dried (V-E-1) and fired (IV-A-11). If products are glazed, they are refired (IV-A-11). Testing and evaluation of results take place in the rooms (V-B, V-C and V-D).

The phase of sanitary and utility ware shaping processes had to be located in another module (No. 5) as it requires further space including also plaster, model and mould shop. Some supplementary tests of casting slurry regarding its viscosity, application of liquefiers, setting time in moulding and other tests not involved in the programme of the workroom of experimental technology (V-D) are carried out in the workroom for casting and turning processes (V-F). Plaster preparation and potter's wheel with accessories for working plaster cases, moulds and models are placed in the room (V-G), drier of plaster models in (V-I). The workshop for casting and turning processes (V-J) is engaged with experimental casting and turning of sanitary and utility ware. The proceeding operations and drying of shaped pieces are carried out on the wet line of the technological workshop (V-E) while firing and glost firing is supposed to take place in the pilot plant for non-metallic products (VII-18). The casting slurry and extruded columns of plastic body are transported for shaping by a platform truck. For larger trials, the wet line of the pilot plant could be applied for casting slurry or plastic body preparation.

The equipment for cement testing is also located in the Module 5. The following tests are executed in the workroom for laboratory cement testing (V-K): cement

fineness determination by Blaine (V-K-3), setting time of concrete testing corpuscles (V-K-4, 5), hydration heat determination (V-K-6), water absorption (V-K-8).

Testing concrete corpuscles are prepared in the workshop for cement testing (V-L-1, 2, 3, 4) where also volume stability is determined by a high pressure autoclave. Compressive strength and bending strength of concrete testing corpuscles are tested in the physical-mechanical testing room in positions (V-C-7) and V-C-8) respectively.

5.4 Arrangement and equipment of the technological laboratory for testing industrial ceramics

A Preparation of experimental corpuscles

Machines:	Pcs
1 - Diamond circular saw	1
2 - Grinding machine for rollers	1
3 - Small circular saw	1
4 - Double-wheel grinder	1
5 - Fine-grinding machine for thin sections	1
Furniture:	
Shelf for samples and measuring aids	1
High laboratory bench	1

B Heat testing room

Instruments and equipment:

1 - Tube graphite electrode furnace incl. transformer and switch board (20 kW) for testing of refractoriness	1
2 - Laboratory kiln with accessories for determination of refractoriness under load	1
3 - Laboratory kiln for determination of refractory bending strength	1
4 - Dilatometer	1
5 - Steger`s instrument for determination of correspondence of body and glaze thermal expansion	1

Furniture:

High laboratory bench	1

C Physical-mechanical testing room

Instruments and equipment:

1 - Technical balance (1000 g)	1
2 - Drier with forced hot air circulation (60 l; 50 - 200°C)	1
3 - Electric or gas heater	1
4 - Vessel for determination of water absorption	3
5 - Instrument for determination of distortion of surfaces	1
6 - Instrument for determination of distortion of surface edges and deviations from the right angle	1

7 - Hydraulic experimental press for determination of compressive strength, pressing of testing corpuscles and experimental products	1
8 - Instrument for determination of bending strength of fired wall and floor tiles and cement testing corpuscles	1

Furniture:

High laboratory bench	1
Laboratory sink	1

D Workroom of experimental technology

Instruments and equipment:

1 - Technical balance (1000 g)	1
2 - Planetary porcelain drum for grinding experimental bodies	1
3 - Laboratory drier with forced hot air circulation (60 l; 50 - 200°C	1
4 - Gradient kiln for determination of optimum firing temperatures	1
5 - Electric laboratory kiln for firing experimental products and testing corpuscles	1
6 - Fister's rammer for testing plastic and ramming masses	1
7 - Equipment for sieve sorting	1

Furniture:

High laboratory bench	2
Laboratory sink	1

E Technological workshop

Machines and equipment:	
1 - Large laboratory drier with forced hot air circulation (60 l, 50 - 200°C)	1
2 - Laboratory crusher	1
3 - Laboratory pan mixer	1
4 - Vibrating sieve (Three-decker)	1
5 - Technical balance up to 10 kg	1
6 - Balance up to 100 kg	1
7 - Ball mill 20 dm^3	1
8 - Ball mill 80 dm^3	1
9 - Laboratory filterpress + container for ceramic slurry with a blunger	1 set
10 - Laboratory pan mill with perforated path	1
11 - Porcelain drum with frame	1
12 - Electrical spray gun for glazing	1
13 - Vessel for glazing	1
14 - Container for raw materials	2
Furniture:	
Low laboratory bench	1
Basin for washing	1

F Workroom for casting and turning processes

Machines and equipment:	
1 - Technical balance (1000 g)	1
2 - Laboratory drier with forced hot air circulation (60 l; 50 - 200°C)	1
3 - Through-flow viscometer	1
4 - Stop watch	1

5 - Spray gun for glazing	1
Furniture:	
Low laboratory table	1

G Plaster case, mould and model workshop

Machines and equipment:	
1 - Mixer for plaster	1
2 - Vessel for plaster	5
3 - Potter's wheel with accessories	1
4 - Box for plaster storing	1
Furniture:	
Low laboratory bench with marble plate	1
High laboratory bench with marble plate	1

H Store for plaster, cement and liquefiers

Equipment:	
Shelf	1

I Chamber drier for plaster cases and moulds

Equipment:	
Steam or electric heating body	2
Furniture:	
Wooden shelf	2

J Workshop for casting and turning processes

Equipment:	
1 - Container for slurry with a blunger	1
2 - Travelling hoisting equipment	1
3 - Truck with vessels for transport of slurry, extruded columns of plastic body and shaped semi-products	1
4 - Metal sheet lined box for wet storing of plastic body	1
5 - Jigger-jolley for turning products from plastic body	1
6 - Potter's wheel for turning products and semi-products	1
7 - Spray gun for glazing	1

Furniture:	
Low laboratory bench	2
High laboratory bench	1
Shelf	1

K Workroom for laboratory cement testing

Machines and equipment:	
1 - Technical balance (1000 g)	1
2 - Equipment for screening	1
3 - Instrument for cement fineness determination (Blaine)	1
4 - Vicat's instrument	1
5 - Calorimeter for hydration heat determination	1
6 - Automatic apparatus for concrete setting time determination	1
7 - Electric or gas heater	1

8 - Vessel for determination of water absorption	1

Furniture:

Low laboratory bench	2

L Workshop for cement testing

Machines and equipment:

1 - Triple-decked vibration sieve	1
2 - Laboratory concrete mixer	1
3 - Shock table	1
4 - Triple moulds for concrete corpuscles	4
5 - High pressure autoclave (8 l, 25 atm)	1
6 - Box for wet storing of testing corpuscles	3

Furniture:

High laboratory bench	2

TESTING INSTITUTE

FOR NON-METALLIC RAW MATERIALS AND PRODUCTS

C

SEMI-INDUSTRIAL SECTION

VI.

Pilot Plant for Non-metallic Raw Material

Beneficiation Trials

6.1 Assignments of the pilot plant for non-metallic raw material beneficiation trials

The pilot plant processes samples of clays, kaolins and sands on a semi-industrial scale to verify the possibility of preparing and upgrading these raw materials. The pilot plant accepts samples of at least 100 kg. The samples undergo the process simulating the production technology of kaolin washing and sand sorting. The pilot plant passes the samples of beneficiated semi-products and final products to the preceding laboratories for evaluation.

6.2 Work organization in the pilot plant

The machines and equipment of two semi-industrial beneficiation lines are installed in the pilot plant:

- the line for kaolin and other plastic clay beneficiation by washing process,
- the wet line for sand beneficiation by sorting process.

This proposal should be considered only as a tentative suggestion. The implementation can take place after preceding recognition of local materials. The suitable beneficiation technologies will depend on their properties.

6.3 Arrangement and equipment of the pilot plant for non-metallic raw materials beneficiation trials

(Module 1, Pilot Plant TI/VI)

Production line for kaolin and plastic clay beneficiation by washing process

	Pcs
1 - Blunger with sand lifter	1
2 - Vibrating screen	1
3 - Hydrocyclone	1
4 - Thickening basin	1
5 - Sedimentation tank	1
6 - Filter press	1
7 - Drier	1

Production line for sand beneficiation by sand sorting

1 - Blunger	1
2 - Vibrating screen	1
3 - Thickener	1
4 - Dewatering equipment	1
5 - Counterflow separator	1
6 - Checking sieve	1
7 - Dewatering equipment	1
8 - Drier	1

TESTING INSTITUTE

FOR NON METALLIC RAW MATERIALS AND PRODUCTS

C

SEMI-INDUSTRIAL SECTION

VII.

Pilot Plant for Semi-industrial Trials in the Manufacture of Non-metallic Products

7.1 Assignments of the pilot plant for semi-industrial trials in the manufacture of non-metallic products

The pilot plant carries out semi-industrial trials with bodies for building ceramic materials, ceramic sanitary and utility ware and refractories developed on laboratory scale in the Technological laboratory for testing non-metallic products. The processed body quantities range as a rule from 100 kg to some hundreds of kg. The equipment of the pilot plant simulates as truly as possible conditions of a manufacturing plant so that the results of the experimental trials can be later implemented with minimum alterations in the production plant. Final products and semi-products are evaluated in the relevant testing laboratories if need be.

7.2 Work organization in the pilot plant for semi-industrial trials in the manufacture of non-metallic products

(Module No. 6, Pilot Plant TI/VII)

Raw materials delivered to the pilot plant are stored in containers. Raw materials requiring a dressing prior to be processed into bodies are ground, sorted into grain size fractions and stored in containers of dressed raw materials. There are two processing lines for body preparation - the wet line preparing bodies by the wet method and geared to the manufacture of ceramic building materials, ceramic sanitary and utility ware and the dry line with dry method for body preparation oriented mainly to the manufacture of refractories.

7.3 Arrangement and equipment of the pilot plant for semi-industrial trials in the manufacture of non-metallic products

(Module No. 6, Pilot Plant TI/VII)

Both the lines for body preparation by wet and dry method are not strictly separated, some machines and equipment being common. The pilot plant has the following equipment:

	Pcs
1 - Technical balance (10 kg)	1
2 - Balance provided with a scale (200 kg)	1
3 - Large chamber drier (200 dm3, 50 - 200°C)	1
4 - Jaw crusher (output 2 - 4 m3/hr)	1
5 - Pan grinder for dry milling (50 - 300 kg/hr)	1
6 - Pan mixer (one batch 5 - 20 min.)	1
7 - Body kneader (one batch 10 - 30 min.)	1
8 - Vacuum worm extruder (for extruding pre-pressed piecer or green products)	1
9 - Hydraulic friction or toggle press (for compacting dry body, semi-dry body or for pre-pressing)	1
10 - Ball mill for wet grinding (fine grinding of bodies or glazes, 1 batch to be ground 120 kg, grinding cycle 8 - 12 hours)	1
11 - Ball mill for wet grinding (for fine grinding of bodies, 1 batch to be ground 220 kg, grinding cycle 8 - 12 hours)	1
12 - Vibration screen	1

13 - Slurry container with mixer (150 x 150 x 100 cm)	1
14 - Filterpress with diaphragm pump	1
15 - Spray drier (for dewatering of body suspension and granulating it as pressing body - output 70 kg of pressing body per minute)	1
16 - Glazing cabin	1
17 - Triple decked vibration screen	1
18 - Electric kiln Superkanthal 1500°C (heating chamber 0.4 m^3)	1
19 - Electric or pneumatic rammer (for compacting ramming masses)	1

TESTING INSTITUTE

FOR NON METALLIC RAW MATERIALS AND PRODUCTS

D

S U P P L E M E N T

Summary of laboratory furniture

The furniture referred to in the lists of laboratory equipment is wood-metal combined modular furniture of increased loading capacity. The furniture assortment represents a modular system enabling combination, completion and extension.

Summary of the above described furniture:

	Pcs
Low laboratory bench at which the operator can sit, operate the instrument and carry out measurements	36
High laboratory bench at which the worker stands and performs work of preparative character	31
Shelf	16
Laboratory sink placed next to a high laboratory bench	6
Laboratory fume cupboard with installed exhaust of detrimental gases	3
Laboratory cabinet for chemicals, glass accessories and spare parts	15
Stable desks imbedded in main walls as supports for analytical balances and other sensitive instruments	2

Equipment of laboratories with precious metals

In chemical analyses of non-metallics it is necessary to decompose samples (by fusing or dissolving) in platinum ovenware. The following set of platinum crucibles and dishes is recommended:

	Pcs
Middle-sized platinum crucible with lid	16
Platinum finger shaped crucibles with lid	8
Platinum dish ø 80 mm	16
Thermocouple Pt-PtRh 10	1

Laboratory chemicals

Average consumption of chemicals for 100 complete analyses of non-metallics (classical method)

Chemicals	g
sodium chloride	1000
potassium chloride	1000
ammonium chloride	250
sodium fluoride	500
sodium nitrate	50
ammonium sulphate	100
sodium carbonate	1500
disodium tetraborate	100
ammonium dihydrogen phosphate	500

	g
hydrochloric acid	7000
perchloric acid	250
sulphuric acid	2000
hydrofluoric acid	7000
nitric acid	1000
boric acid	100
glacial acetic acid	2500
ascorbic acid	50
ammonium hydroxide	3500
sodium hydroxide	250
potassium hydroxide	1000
chelaton	500
ammonium acetate	4000
sodium acetate	500
zinc acetate	500
hydroxide diammonium chloride	250
urotropine	1000
ethanol	100
xylenol orange	10
fluorexon	5
orichrome black T	5
2,2´- dipyridyl	5
tiron	5
iron of pure spectrum	3
titanium dioxide of pure spectrum	5
coloured silicagel	2000
set of buffer solutions	2 pcs

The listed chemicals are of purity pro analysi (p.a.)

Average consumption of chemicals for 100 complete non-metallic analyses (atomic absorption spectrophotometry)

Chemicals	g
hydrochloric acid	5000
perchloric acid	250
hydrofluoric acid	3000
sulphuric acid	500
sodium chloride	250
potassium chloride	250
cesium chloride	50
strontium oxide	100
lanthanum oxide	50
oxichinoline	500
lithium metaborate	1000
set of standard solutions (Si, Al, Fe, Ti. Mg, Ca, Pb, Cu, Mn, Cd)	1 pc

Chemicals for technological laboratory for testing non-metallic raw materials

Approximately the following quantities of chemicals should be on stock:

Chemicals	g
sodium carbonate	250
ammonium hydroxide	1000
glacial acetic acid	1000
barium sulphate	250
coloured silicagel	2000

Chemicals for technological laboratory for testing non-metallic products

Required quantities of stored chemicals:

	kg
sodium phyrophosphate	50
sodium carbonate	50
ammonium hydroxide	50
acetic acid	10

Laboratory aids

Aids for analytical laboratory

The laboratory should be equipped by chemical glass and laboratory porcelain as follows:

Aid	Pcs
weighing bottle (ø 40 mm) low shape	24
desiccator (ø 300 mm)	1
desiccator (ø 150 mm)	1

fast filter funnel (ø 60 mm)	112
volumetric flask (50 ml)	12
volumetric flask (100 ml)	12
volumetric flask (500 ml)	6
volumetric flask (1000 ml)	6
beaker (250 ml) low shape	12
beaker (500 ml) low shape	12
beaker (800 ml) high shape	12
pipette (1 ml)	3
pipette (5 ml)	6
pipette (10 ml)	6
pipette (20 ml)	3
pipette (50 ml)	3
automatic burette (20 ml)	2
automatic burette (50 ml)	2
reagent bottle (1000 ml)	6
bottle for indicators	6
porcelain dish (ø 150 mm)	12
filter paper blue band (100 pcs)	2
filter paper white band (100 pcs)	4

Laboratory aids for technological laboratory for testing non-metallic raw materials

The list of necessary aids for technological laboratory is shown below:

Aid	Pcs
sedimentation cylinder by Andreasen	6
sucking glask (5000 ml)	6
desiccator (ø 350 mm)	2
desiccator (ø 250 mm)	2

pipette (5 ml) calibrated	2
weighing bottle (ø 60 mm) low shape	24
weighing bottle (ø 50 mm) low shape	24
beaker (250 ml) low shape	12
beaker (600 ml) high shape	12
beaker (1000 ml) low shape	12
reagent bottle (5000 ml) wide neck	12
Büchner funnel (ø 250 mm)	6
porcelain dish (ø 50 mm) medium shape	24
porcelain dish (ø 100 mm) low shape	24
porcelain dish (ø 150 mm) medium shape	24
polyethylene flask (500 ml) wide neck	24
polyethylene flask (1000 ml) wide neck	24
plastic dish (400 mm)	3
plastic bucket (5 l)	6
porcelain crucible (50 ml) high shape	48
laboratory thermometer (0 - 50°C)	2
slide gauge	1
filter paper blue band (100 pcs)	3
filter paper black band (100 pcs)	3

Laboratory aids for technological laboratory for testing non-metallic products

Aid	Pcs
slide rules 250 and 500 mm	2
flat dish 30x50x5 cm for manual glazing	1
protractor	1
angle iron with measuring wedges	1
bucket 10 - 15 l made from plastics	5
calibrated glass vessel (1 l)	3
calibrated glass vessel (3 l)	3
calibrated glass vessel (5 l)	3

Required electric power input (KW)
for laboratories and pilot plants

	3x380/220 V	220 V
I. Laboratory for preparation of samples	6	10
II. Laboratory for analytical chemistry	20	15
III. Laboratory for physical chemistry and mineralogy	-	15
IV. Technological laboratory for testing non-metallic raw materials	10	10
V. Technological laboratory for testing non-metallic products	48	38
VI. Pilot plant for non-metallic raw material beneficiation trials	50	15
VII. Pilot plant for semi-industrial trials of non-metallic products	138	1

Built up area and space

Built up area and built up space of operational part of the Testing Institute

The laboratories and pilot plants are located on 6 modules 15 x 9 m; the rooms should be 4 m high.

Built up area of all modules being one-storied	810 m^2
Built up space	3,240 m^3

These data do not include area and space for management of the Institute, administration, maintenance workshop, social conveniences, etc.

KAOLIN WASHING PLANT

TESTING LABORATORY

KAOLIN WASHING PLANT

TESTING LABORATORY

I.

CHEMICAL LABORATORY

1.1 Assignments of the chemical laboratory in a kaolin washing plant

The task of the laboratory consists in continuous evaluation of raw material to be processed.

The raw material from the mining fore-land is assessed with regard to its ferric oxide and titanium dioxide contents. The samples for these basic determinations are taken from petrologically congruent blocks of deposit (if more quarries are exploited then from each quarry) in order that mixing ratios of raw material varieties of different values delivered to the washing plant may be determined. The obtained results and the correct selection of mixing ratios are the basic preconditions for the manufacture of final product of sufficient quality with minimum fluctuation of basic parameters.

The quality of the final product (washed kaolin) is evaluated from the view of chemical composition according to the basic chemical parameters. Contents of aluminum oxide, ferric oxide, titanium dioxide and calcium oxide are determined in wet extracts from ceramic kaolins and kaolins for paper industry.

The laboratory is equipped for its work with suitable instruments and aids so that the production management may receive precise information on quarrying, beneficiation and expedition.

It is advisable to order regularly (in two-month intervals) final product (washed kaolin) testing in the Testing Institute for Non-metallic Raw Materials and Products covering the complex chemical analysis. Statistically processed results furnish then a useful information for the production control.

1.2 Work organization in the chemical laboratory of a kaolin washing plant

The contents of Al_2O_3, Fe_2O_3 and TiO_2 in kaolin samples taken from laboratory washout of raw material are determined. The same oxides and CaO contents in final product samples are determined from the leach.

Samples for chemical analysis are dried, fine ground to the fineness for analysis, redried at $110^{\circ}C \pm 5^{\circ}C$ to a stabilized mass and the analytical sample is weighed. This sample is decomposed by fusing with sodium carbonate. After conversion of the smelt into solution, SiO_2 is segregated and separated by filtration. The content of Al_2O_3 in the filtrate is determined by titration, Fe_2O_3 and TiO_2 contents by photometry. CaO is determined by the complexometric method in the leach prepared from a separately weighed dose.

1.3 Arrangement and equipment of the chemical laboratory in a kaolin washing plant (Module No. 7, Lab. KW I)

Chemical laboratory

Instruments:	Pcs
1 - Analytical semi-automatic balance (100 g)	1
2 - Electric hot air drier (60 l)	1
3 - Equipment for decomposition of samples by fusion (4 Mecker burners, 4 stands, 4 triangles)	1 set
4 - Sand bath	1
5 - Water bath	1
6 - Electric heater	1
7 - Electric muffle kiln (1200°C, 6 dm^3)	1
8 - Electric mixer	1
9 - Transportable pH meter	1
10 - Single-beam spectrophotometer for photocolorimetry, turbidity measurements, photometric and fluorimetric titration (400 - 800 nm)	1
11 - Glass distillation apparatus (4.5 l distilled water per hour)	1
12 - Two-beam photometer (400 - 700 nm)	1

KAOLIN WASHING PLANT

TESTING LABORATORY

II.

TECHNOLOGICAL LABORATORY

2.1 Assignments of the technological laboratory in a kaolin washing plant

The laboratory evaluates continuously main technological parameters of raw material beneficiation process and final product (washed kaolin). It could test also selected plastic clays subjected to the washing process if this procedure in particular cases is economically effective.

The raw material from the mining fore-land for samples is identical with that one taken for chemical testing.

The observance of the beneficiation technology is followed and corrected by measuring and regulation technique installed at particular machines and equipment of a washing plant. The laboratory checks the grainage of sieve residues after hydrocyclones and volume density of suspensions prior to dewatering.

The quality of the final product is evaluated according to the main technological parameters. Humidity, sieve (0.063 mm) residue, apparent dynamic viscosity and bending strength after drying - are the tested properties of ceramic kaolins. Kaolins for paper industry are subjected to the tests of humidity, residues on sieves 0.2, 0.09, 0.063 mm and particle content under 2 microns are ascertained, whiteness and abrasivity are measured.

The findings must be promptly delivered to production management for application.

The samples of final product should be sent regularly (in two-month intervals) to the Testing Institute for Silicate Raw Materials and Products for testing their mineralogical characteristics and further physical-chemical parameters if need be.

2.2 Work organization in the technological laboratory of a kaolin washing plant

The washout content of raw material (particles under 20 microns) is determined, sieve residues and volume density of semiproducts are ascertained, humidity, sieve residues, particle content under 2 microns, apparent dynamic viscosity, bending strength, whiteness and abrasivity of final product (kaolin) are measured.

The samples for washout determination are predried, carefully ground and wet screened for separation of the sand fraction (above 2 mm) from the fine sand fraction (0.063 - 2.0 mm). The fraction under 0.063 mm is collected and divided by sedimentation into slurry (0.020 - 0.063 mm) and kaolin fraction (under 0.020 mm). The kaolin fraction is dewatered by vacuum filtration. Sand, slurry and kaolin fractions are dried and their distribution is calculated as percentages of the dry weighed dose.

Semiproducts have to undergo the tests of sieve residues (0.063 and 0.09 mm) by wet screening machine and volume density of suspensions by mass determination of a certain volume.

Final products are subjected to tests of humidity being dried to 110°C. Sieve residues (0.2, 0.09, 0.063 mm) are separated by screening machine and representation after drying is expressed in percentages. The fraction content under 2 microns is determined by the sedimentation method by Andreasen from the sample of 1% dispersed suspension. Apparent dynamic viscosity is determined as the outflow duration of a dispersed suspension sample (L:1) by the through-flow viscometer and the obtained value is recalculated according to the standard. The testing of bending strength proceeds in such a way that bars shaped from plastic body or cast from slip (270x40x13 mm) are dried and tested by a bending strength tester. Whiteness of kaolin samples (mixed by prescribed methods and prepared as tablets) is determined by remission photometer (a sensitive apparatus - placed therefore in the chemical laboratory). The calibration standard is barium sulphate with verified absolute whiteness. Abrasivity is assessed according to the abrasion of experimental sieve, the surface of which was exposed to the mechanical action of a roller made of plastics in the suspension of the tested sample.

2.3 Arrangement and equipment of the technological laboratory in a kaolin washing plant (Module No. 7, Lab. KW II)

Instruments:	Pcs
1 - Screening machine for wet and dry screening applicable as vibrating mill for preparation of samples to chemical analyses	1

2	Laboratory mixer	1
3	Electric hot air drier (200 l)	1
4	Digital quick balance (1000 g)	1
5	Laboratory mixer	1
6	Equipment for wet sorting by sedimentation for determination of kaolin content in washed suspensions	1
7	Stop watch for measuring duration of sedimentation	1
8	Rotary vacuum pump	1
9	Bench for vacuum filtration (vacuum distribution, 4 sucking flasks 5000 ml)	1
10	Equipment for determination of particle content under 2 microns (4 Andreasen cylinders in tempering bath)	1
11	Through-flow viscometer	1
12	Equipment for preparation of testing corpuscles	1
13	Bending strength tester for determination of bending strength of testing bars	1
14	Abrasivity tester (used for testing kaolin for paper industry)	1

KAOLIN WASHING PLANT

TESTING LABORATORY

III.

S U P P L E M E N T

3.1 Summary of furniture for kaolin washing plant testing laboratory

	Pcs
High laboratory bench	8
Laboratory sink	4
Low laboratory bench	12
Table for analytical balance	1
Fume cupboard with installed exhaust od detrimental gases	1
Laboratory cabinet	5

3.2 Equipment of chemical laboratory with precious metals

Middle sized platinum crucible with lid	4

3.3 Laboratory chemicals

Chemical laboratory

Consumption of chemicals for 100 analyses (Al_2O_3, Fe_2O_3, TiO_2, CaO)
Required purity: p.a.

Chemicals:	g
potassium chloride	250
sodium fluoride	500
sodium nitrate	50
ammonium sulphate	100

sodium carbonate	1500
disodium tetraborate	100
chelaton 3	500
ammonium acetate	4000
sodium acetate	500
zinc acetate	500
ammonium chloride	100
urotropine	500
ethanol	100
hydrochloric acid	5000
sulphuric acid	500
hydrofluoric acid	2000
nitric acid	3000
glacial acetic acid	2500
ascorbic acid	50
ammonium hydroxide	1500
potassium hydroxide	500
xylene orange	10
fluorexon	5
2.2 - dipyridyl	5
tiron	5
iron of pure spectrum	3
titanium oxide of pure spectrum	10
silicagel coloured	1000
set of buffer solutions	1

Chemicals for technological laboratory to be on stock

Chemicals:	g
sodium carbonate	250
ammonium hydroxide	1000
glacial acetic acid	1000
barium sulphate	250
coloured silicagel	2000

3.4 Laboratory aids

Aids for chemical laboratory:

Aid	Pcs
weighing bottle (ø 40 mm) low shape	24
desiccator (ø 300 mm)	1
desiccator (ø 150 mm)	1
fast filtering funnel (ø 60 mm)	112
volumetric flask (50 ml)	12
volumetric flask (100 ml)	12
volumetric flask (500 ml)	6
volumetric flask (1000 ml)	6
beaker (250 ml) low shape	12
beaker (500 ml) low shape	12
beaker (800 ml) high shape	12
pipette (1 ml)	3
pipette (5 ml)	6
pipette (10 ml)	6
pipette (20 ml)	3
pipette (50 ml)	3

automatic burette (20 ml)	2
automatic burette (50 ml)	2
reagent bottle (1000 ml)	6
bottle for indicators	6
porcelain dish (ø 150 mm)	12
filter paper blue band (100 pcs)	2
filter paper white band (100 pcs)	4

Aids for technological laboratory

Aid	Pcs
sedimentation cylinder by Andreasen	6
sucking flask (5000 ml)	6
desiccator (ø 350 mm)	2
desiccator (ø 250 mm)	2
pipette (5 ml) calibrated	2
weighing bottle (ø 60 mm) low shape	24
weighing bottle (ø 50 mm) low shape	24
beaker (250 ml) low shape	12
beaker (600 ml) high shape	12
beaker (1000 ml) low shape	12
reagent bottle (5000 ml) wide neck	12
Büchner funnel (ø 250 mm)	6
porcelain dish (ø 50 mm) medium shape	24
porcelain dish (ø 100 mm) low shape	24
porcelain dish (ø 150 mm) medium shape	24
polyethylene flask (500 ml) wide neck	24
polyethylene flask (1000 ml) wide neck	24
plastic dish (ø 400 mm)	3
plastic bucket (5 l)	6

porcelain crucible (50 ml) high shape	48
laboratory thermometer (0 - 50°C)	2
slide gauge	1
filter paper blue band (100 pcs)	3
filter paper black band (100 pcs)	3

3.5 Required electric power input (kW) for laboratories

	220 V
Chemical laboratory	13
Technological laboratory	10

Both the laboratories are located in the module No. 7 (15 x 9 m)

Built up area	135 m^2
Built up space	540 m^3

TESTING LABORATORY OF A PLANT MANUFACTURING CERAMIC PRODUCTS

TESTING LABORATORY OF A PLANT

MANUFACTURING CERAMIC PRODUCTS

I.

CHEMICAL-PHYSICAL LABORATORY

1.1 Assignments of the chemical-physical laboratory in a plant manufacturing ceramic products

The basic task of the chemical-physical laboratory consists in testing continuously chemical and physical properties of raw materials, semi-products and products in the manufacture of ceramic building materials, sanitary and utility ware. However, the laboratory is devised to be adaptable to the extension of product assortment and to local conditions.

The laboratory carries out these tests:

Complete chemical analyses of raw materials, semi-products and products if need be. The loss on ignition is determined for SiO_2, Al_2O_3, TiO_2, Fe_2O_3, CaO, MgO, K_2O, Na_2O.

Abridged analyses of raw materials, semi-products and products if need be. The loss on ignition is determined for SiO_2, Al_2O_3, Fe_2O_3, TiO_2, CaO, MgO.

Determination of grain size distribution of raw materials and semi-products.

Determination of water absorption by vacuum method.

Viscosity determination of slurries.

1.2 Work organization in the chemical-physical laboratory

The samples of semi-products and products are received from the technological laboratory where they are registered and stored. Samples for chemical analyses are dried, crushed if necessary, quartered and ground to the fineness for analysis. A part is delivered to

the analytical laboratory for analysis, the remainder is returned to store of samples to be available for additional analysis if need be.

Samples for physical tests are prepared in the preparatory room for testing corpuscles in the technological laboratory.

1.3 Arrangement and equipment of the chemical-physical laboratory for testing ceramic building materials (Module No. 8, Lab. CP/I)

A Preparation of analytical samples

Machine and equipment:	Pcs
1 - Drier (60 l, 50 - 200°C)	1
2 - Laboratory jaw crusher	1
3 - Screening machine incl. vibration mill for dry and wet screening	1
4 - Balance (1000 g)	1

Furniture:

Low laboratory bench	1
High laboratory bench	1
Laboratory cabinet	1

B Weighing

Instruments:

1 - Analytical balance (100 g)	1
2 - Quick balance (200 g)	1

Furniture:

Low laboratory bench	1
Stable inbedded desk	1

C Fume cupboards

Instruments:

1 - Mecker burner	4
2 - Sand bath	1
3 - Water bath	1
4 - Heater (for digestion flasks 250, 500 ml)	2

Furniture:

Fume cupboard	2
Low laboratory bench	2

D Compressor and pressure vessels

Machines and equipment:

1 - Compressor with pressure container	1
2 - Pressure vessel (acetylene, oxygen)	2

E Vacuum station and flame photometer

Machines and equipment:

1 - Vacuum pump	1
2 - Flame photometer for determination of K_2O and Na_2O	1
3 - Vacuum vessel for water absorption determination	1
4 - Vacuum distribution incl. 4 sucking flasks and 4 Büchner funnels	1

Furniture:

Low laboratory bench	1

F Preparative chemistry

Instruments:

1 - Single-beam spectrophotometer	1
2 - pH meter (0 - 14 pH; 340 - 800 nm)	1
3 - Electromagnetic mixer	1
4 - Drier (60 l, 50 - 200°C)	1
5 - Electric furnace, useful v. 24x38x22 cm. 1200°C	1
6 - Glass distillation apparatus (12 l p.h.)	1

Furniture:

High laboratory bench	4
Low laboratory bench	2
Laboratory sink	2
Cabinet for laboratory glass and chemicals	2

G Microscopy and evaluation of results

Instruments:

1 - Polarizing microscope	1
2 - Calculator	1

Furniture:

Low laboratory bench	2
Laboratory cabinet for documents	1
Laboratory cabinet with armoured box for deposition of poisons and precious metals	1

H Store of glass and chemicals

Furniture:	
Shelf	4

I Shower bath

Equipment	1 set

TESTING LABORATORY OF A PLANT MANUFACTURING CERAMIC PRODUCTS

II.

TECHNOLOGICAL LABORATORY FOR TESTING CERAMIC PRODUCTS

2.1 Assignments of the technological laboratory for testing ceramic products

The task of the technological laboratory is to carry out technological tests of raw materials for the manufacture of ceramic building materials, sanitary and utility ware, to test mechanical-physical and technological properties of semi-products and products and to control body and glaze composition in these industries. The project of the laboratory permits the extension of testing on further products and adaptability to local conditions.

The following main properties of raw materials are tested: critical humidity by Bigot, plasticity, dry shrinkage and firing shrinkage at different temperatures, bending strength, water absorption after firing to different temperatures, appearance of fired products, etc.

Semi-products and products are subjected to the following tests: content of water of plasticity, granulometry and washed-out residues of wet-ground bodies, bending strength of pressed, dried and fired pieces and products, drying and firing shrinkage, water absorption of fired pieces and products, glaze resistance against cracking, frost resistance (for outer walling), abrasivity.

Tests of body composition are carried out if changes of body recipes are necessary, e.g. in case of insufficient properties of products, in changing raw material basis, etc. Glaze composition is tested

especially if ware assortment is changed or extended, new frits and raw materials for glazes delivered, etc.

2.2 Work organization in the technological laboratory for testing ceramic products

Samples of raw materials to be tested are taken by entrusted technician in the store of raw materials or directly from transport vehicles unloading raw materials. The average humidity content of raw material is determined for the following recipe adjustment to the found humidity and the above properties are tested. Samples of semi-finished products are taken directly from the production process and tests are carried out promptly for immediate intervention to take place in the production process if necessary. Samples of finished products are taken immediately at the kiln exit and tested also without delay for immediate measures to be taken in the production process if some properties are not satisfactory.

Body and glaze compositions are tested with average raw material and glaze samples. They are taken in such a way as to correspond to the average of the whole stock. The same applies to frits and further raw materials for glaze manufacture.

2.3 Equipment and arrangement of technological laboratory for testing ceramic products

(Module No. 9, Lab. CP/II)

A Room for reception, registration and storing of samples and elaboration of reports

Furniture:	Pos
Table	1
Low laboratory bench	1
Shelf for samples and files	3

B Preparation of testing corpuscles

Machines:

1 - Circular sawing machine with diamond wheel	1
2 - Small circular sawing machine	1
3 - Grinding machine with two discs	1
4 - Grinding machine for polished sections	1

Furniture:

Low laboratory bench	1
Shelf	1

C Heat testing

Machines and instruments:

1 - Dilatometer	1
2 - Steger's instrument	1
3 - Electric furnace (24x38x22 cm, 1200 °C)	1

4 - Gradient tube furnace	1
Furniture:	
Low laboratory bench	1
High laboratory bench	1

D Physical and mechanical testing

Machines and instruments:	
1 - Technical balance (1000 g)	1
2 - Drier with forced air circulation (60 l, 50 - 200°C)	1
3 - Electric or gas heater	1
4 - Vessel for determination of water absorption	1
5 - Instrument for determination of surface distortion .	1
6 - Instrument for determination of surface edges and deviations from right angle	1
7 - Instrument for bending strength determination after pressing and drying for wall and floor tiles, sanitary and utility ware (testing corpuscles)	1
8 - Instrument for bending strength determination after firing for wall and floor tiles, sanitary and utility ware (testing corpuscles)	1

Furniture:

Low laboratory bench	1
High laboratory bench	1
Laboratory sink	1

E Workroom of experimental technology

Instruments:

1 - Technical balance (1000 g)	1
2 - Planetary porcelain drum	1
3 - Laboratory drier (50 - 200°C)	1
4 - Equipment for sieve sorting	1

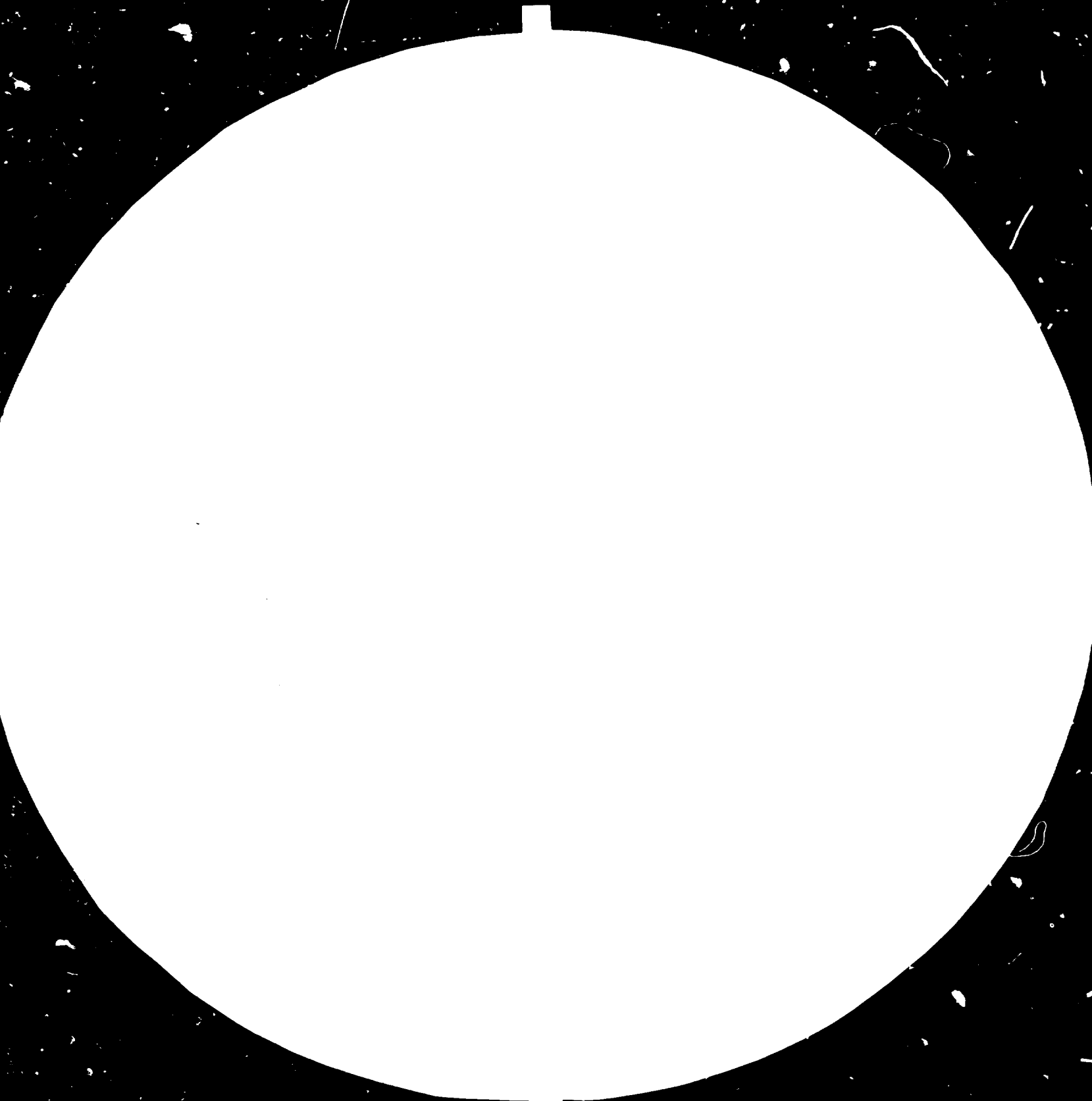
Furniture:

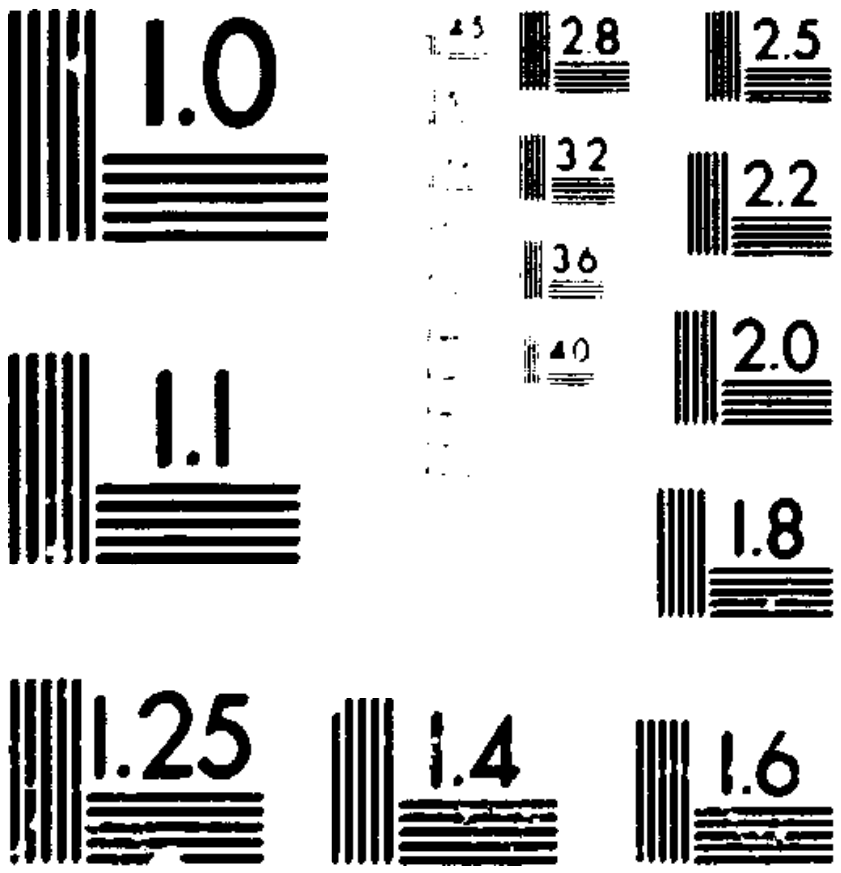
Low laboratory bench	1
High laboratory bench	1
Laboratory sink	1

F Technological workshop

Machines and equipment:

1 - Large laboratory drier	1
2 - Balance up to 100 kg	1
3 - Technical balance up to 10 kg	1
4 - Ball mill (20 dm^3)	1
5 - Ball mill (80 dm^3)	1
6 - Laboratory filter-press + container for ceramic slurry with a blunger	1
7 - Laboratory pan mill with perforated path	1
8 - Porcelain drum with frame	2
9 - Electrical spray gun	1





10 - Vessel for glazing	1
11 - Friction, hydraulic or knuckle-joint press	1
12 - Muffle kiln, rated temperature 1250°C	1
13 - Laboratory vacuum extruder	1
14 - Jigger-jolley	1
15 - Potter`s wheel	1

Furniture:

Container for raw materials	1
High laboratory bench	1
Basin for washing aids	1

TESTING LABORATORY OF A PLANT MANUFACTURING CERAMIC PRODUCTS

III.

S U P P L E M E N T

3.1 Summary of laboratory furniture for the testing laboratory of a plant producing ceramic building materials, sanitary and utility ware

	Pcs
Low laboratory bench	14
High laboratory bench	8
Laboratory sink	4
Laboratory fume cupboard	2
Laboratory cabinet	5
Stable desk inbedded in wall	1
Shelf	8

3.2 Equipment of laboratories with precious metals

	Pcs
Middle sized platinum crucible with lid	4

3.3 Laboratory chemicals

Consumption of chemicals for 100 complex analyses (classical method)

See part TESTING INSTITUTE FOR NON METALLIC RAW MATERIALS AND PRODUCTS - D Supplement, page 52

Chemicals for technological laboratory of a plant producing ceramic building materials, sanitary and utility ware

Approximately the following quantities of chemicals should be on stock:

Chemicals	g
sodium carbonate	250
ammonium hydroxide	1000
glacial acetic acid	1000
barium sulphate	250
coloured silicagel	2000

Required quantities of stored chemicals - quality for industrial use:

Chemicals	kg
sodium phyrophosphate	50
sodium carbonate	50
ammonium hydroxide	50
acetic acid	10

3.4 Laboratory aids for chemical-physical laboratory of a plant producing ceramic building materials, sanitary and utility ware

The laboratory should be equipped by chemical glass and laboratory porcelain as follows:

Aid	Pcs
weighing bottle (ø 40 mm) low shape	24
desiccator (ø 300 mm)	1
desiccator (ø 150 mm)	1
fast filter funnel (ø 60 mm)	12
volumetric flask (50 ml)	12
volumetric flask (100 ml)	12

volumetric flask (500 ml)	6
volumetric flask (1000 ml)	6
beaker (250 ml) low shape	12
beaker (500 ml) low shape	12
beaker (800 ml) high shape	12
pipette (1 ml)	3
pipette (5 ml)	6
pipette (10 ml)	6
pipette (20 ml)	3
pipette (50 ml)	3
automatic burette (20 ml)	2
automatic burette (50 ml)	2
reagent bottle (1000 ml)	6
bottle for indicators	6
porcelain dish (ø 150 mm)	12
filter paper blue band (100 pcs)	2
filter paper white band (100 pcs)	4

Laboratory aids for technological laboratory of a plant producing ceramic building materials, sanitary and utility ware

a) Testing of raw materials

Aid	Pcs
sedimentation cylinder by Andreasen	6
sucking flask (5000 ml)	6
desiccator (ø 350 mm)	2
desiccator (ø 250 mm)	2
pipette (5 ml) calibrated	2
weighing bottle (ø 60 mm) low shape	24
weighing bottle (ø 50 mm) low shape	24

beaker (250 ml) low shape	12
beaker (600 ml) high shape	12
beaker (1000 ml) low shape	12
reagent bottle (5000 ml) wide neck	12
Büchner funnel (ø 250 mm)	6
porcelain dish (ø 50 mm) medium shape	24
porcelain dish (ø 100 mm) low shape	24
porcelain dish (ø 150 mm) medium shape	24
polyethylene flask (500 ml) wide neck	24
polyethylene flask (1000 ml) wide neck	24
plastic dish (ø 400 mm)	3
plastic bucket (5 l)	6
porcelain crucible (50 ml) high shape	48
laboratory thermometer (0 - 50°C)	2
slide gauge	1
filter paper blue band (100 pcs)	3
filter paper black band (100 pcs)	3

b) Testing of semi-products and products

Aid	Pcs
slide rules 250 and 500 mm	2
flat dish 30x50x5 cm for manual glazing	1
protractor	1
angle iron with measuring wedges	1
bucket 10 - 15 l made from plastics	5
calibrated glass vessel (1 l)	3
calibrated glass vessel (3 l)	3
calibrated glass vessel (5 l)	3

3.5 Required electric power input (kW) for testing ceramic building materials, sanitary and utility ware

	3 x 380/220 V	220 V
Chemical-physical and technological laboratories	94	21

Built up area

Chemical-physical laboratory	135 m^2
Technological laboratory	135 m^2

Built up space

Chemical-physical laboratory	540 m^3
Technological laboratory	540 m^3

TESTING LABORATORY OF A PLANT

MANUFACTURING REFRACTORIES

TESTING LABORATORY OF A PLANT

MANUFACTURING REFRACTORIES

I.

CHEMICAL-PHYSICAL LABORATORY

1.1 Assignments of the chemical-physical laboratory in a plant manufacturing refractories

The basic task of the chemical-physical laboratory consists in testing continuously chemical and physical properties of refractory raw materials, semi-products and products embracing
alumino-silicate refractories (alumina and aluminous refractories, fireclay based refractories, semi-silica and siliceous refractories, silica bricks),
basic refractories (magnesite, chromemagnesite and forsterite products, chrome refractories and dolomite bricks),
special refractories (insulating, graphite based, zircon and special oxide refractories),
ramming, castable and mouldable mixes.

The laboratory carries out these tests:

Complete chemical analyses of raw materials, semi-products and products if need be. The loss on ignition is determined for SiO_2, Al_2O_3, TiO_2, Fe_2O_3, CaO, MgO, K_2O, Na_2O.

Abridged analyses of raw materials, semi-products and products if need be. The loss on ignition is determined for SiO_2, Al_2O_3, Fe_2O_3, TiO_2, CaO, MgO.

Determination of grain distribution of raw materials and semi-products.

Determination of water absorption by vacuum method.

Viscosity determination of slurries.

1.2 Work organization in the chemical-physical laboratory

The samples of semi-products and products are received from the technological laboratory where they are registered and stored. Samples for chemical analyses are dried, crushed if necessary, quartered and ground to the fineness for analysis. A part is delivered to the chemical laboratory for analysis, the remainder is returned to store of samples to be available for additional analysis if need be.

Samples for physical tests are prepared in the preparatory room for testing corpuscles in the technological laboratory.

1.3 Arrangement and equipment of the chemical-physical laboratory for testing refractories

(Module No. 10, Lab. R/I)

A Preparation of analytical samples

Machines and equipment:	Pcs
1 - Drier (60 l, 50 - 200°C)	1
2 - Laboratory jaw crusher	1
3 - Screening machine incl. vibration mill for dry and wet screening	1
4 - Balance (1000 g)	1

Furniture:	
Low laboratory bench	1
High laboratory bench	1
Laboratory cabinet	1

B Weighing

Instruments:

1 - Analytical balance (100 g)	1
2 - Quick balance (200 g)	1

Furniture:

Low laboratory bench	1
Stable inbedded desk	1

C Fume cupboards

Instruments:

1 - Mecker burner	4
2 - Sand bath	1
3 - Water bath	1
4 - Heater (for digestion flasks 250, 500 ml)	2

Furniture:

Fume cupboard	2
Low laboratory bench	2

D Compressor and pressure vessels

Machines and equipment:

1 - Compressor with pressure container	1
2 - Pressure vessel (acetylene, oxygen)	2

E Vacuum station and flame photometer

Machines and equipment:

1 - Vacuum pump	1
2 - Flame photometer for determination of K_2O and Na_2O	1

3 - Vacuum vessel for water absorption determination	1
4 - Vacuum distribution incl. 4 sucking flasks and 4 Büchner funnels	1

Furniture:

Low laboratory bench	1

F Preparative chemistry

Instruments:

1 - Single-beam spectrophotometer	1
2 - pH meter (0 - 14 PH, 340 - 800 nm)	1
3 - Electromagnetic mixer	1
4 - Drier (60 l, 50 - 200°C)	1
5 - Electric furnace, useful v. 24x38x22 cm, 1200°C	1
6 - Glass distillation apparatus (12 l p.h.)	1

Furniture:

High laboratory bench	4
Low laboratory bench	2
Laboratory sink	2
Cabinet for laboratory glass and chemicals	2

G Microscopy and evaluation of results

Instruments:

1 - Polarizing microscope	1
2 - Calculator	1

Furniture:	
Low laboratory bench	2
Laboratory cabinet for documents	1
Laboratory cabinet with armoured box for deposition of poisons and precious metals	1

H Store of glass and chemicals

Furniture:	
Shelf	4

I Shower bath

Equipment	1 set

TESTING LABORATORY OF A PLANT MANUFACTURING REFRACTORIES

II.

TECHNOLOGICAL LABORATORY

2.1 Assignments of the technological laboratory

The task of the technological laboratory is to carry out technological tests of raw materials for the manufacture of refractories, to test mechanical-physical--technological properties of refractory semi-products and products, to follow body composition and technological parameters in the production of refractories. The range of tested refractories is referred to in chapter 1.1.

The following properties of raw materials are mainly tested: humidity by Bigot, plasticity, shrinkage after drying and shrinkage after firing at different temperatures, compressive strength, water absorption at different temperatures, appearance of fired pieces, refractoriness, etc.

Semi-products and products are subjected to the tests of water of plasticity, grain size distribution of bodies, compressive strength, refractoriness, refractoriness under load, additional linear changes, physical properties and resistance against slag attack, etc. if need be.

The bodies have to undergo the tests of body composition if necessary, e.g. if the properties of products are not satisfactory, in changing raw materials or introducing a new assortment of products.

2.2 Work organization in a technological laboratory for testing refractories

The samples for testing are taken from the store of raw materials or directly from transport vehicle during unloading. An average humidity content is determined for the recipe to be adjusted to the humidity of raw materials and then the above mentioned properties of raw materials are tested.

The samples of semi-products are taken directly from the production process and tested without delay for relevant measures to be taken immediately in the production process if some tests indicated insufficient properties.

The samples of products are taken immediately after firing and tested also without delay for necessary steps to be taken in the manufacturing phase in case of worse quality indication.

The tests of body composition are carried out with average raw material samples taken from the store in such a way as to represent the average of the shole stock.

2.3 Equipment and arrangement of the technological laboratory for testing refractories

(Module No. 11, Lab. R/II)

A Room for reception, registration and storing of samples and elaboration of reports

Furniture:	Pcs
Table	1
Low laboratory bench	1
Shelf for samples and files	3

B Preparation of experimental corpuscles

Machines:

1 - Circular sawing machine with diamond wheel	1
2 - Grinding machine for rollers	1
3 - Small circular sawing machine	1
4 - Grinding machine with two discs	1
5 - Vertical drilling machine	1

Furniture:

Low laboratory bench	1
Shelf for samples and measuring aids	1

C Heat testing

Machines and equipment:

1 - Tube furnace with graphite electrode incl. transformer and switch board for testing refractoriness	1
2 - Kiln incl. accessories for the determination of refractoriness under load	1
3 - Kiln for determination of additional linear changes (useful v. 18x31x18 cm, 1600°C)	1

D Physical and mechanical testing

Machines and equipment:

1 - Technical balance incl. suspension for hydrostatic weighing	1
2 - Laboratory drier (60 l, 50 - 200°C)	1
3 - Electrical or gas heater	1
4 - Vessel for water absorption determination	1
5 - Experimental hydraulic press	1

Furniture:

Low laboratory bench	1
Laboratory sink	1

E Workroom of experimental technology

Machines, instruments and equipment:

1 - Technical balance (1000 g)	1
2 - Laboratory drier (60 l, 50 - 200°C)	1
3 - Electric kiln (24x38x22 cm useful v., 1200°C)	1
4 - Fisher's rammer	1
5 - Equipment for sieve sorting	1

Furniture:

Low laboratory bench	1
High laboratory bench	1
Laboratory sink	1

F Technological workshop

Machines and equipment:

1 - Large laboratory drier	1
2 - Laboratory pan mixer	1

3 - Jaw crusher	1
4 - Vibration three-decker sieve	1
5 - Technical balance up to 10 kg	1
6 - Ball mill 80 dm^3 for wet grinding	1
7 - Ball mill for dry grinding	1
8 - Laboratory pan mill with perforated path	1
9 - Kneader	1
10 - Vacuum pugmill	1
11 - Hydraulic press	1
12 - Electric kiln, rated temperature 1600°C	1
13 - Electrical or pneumatic rammer	1

Furniture:

Low laboratory bench	1
High laboratory bench	1
Container for raw materials	2
Basin for washing laboratory aids	1

TESTING LABORATORY OF A PLANT

MANUFACTURING REFRACTORIES

III.

S U P P L E M E N T

3.1 Summary of laboratory furniture for the testing laboratory of a plant manufacturing refractories

	Pcs
Low laboratory bench	14
High laboratory bench	7
Laboratory sink	4
Laboratory fume cupboard	2
Laboratory cabinet	5
Stable desk inbedded in wall	1
Shelf	8

3.2 Equipment of laboratories with precious metals

Middle sized platinum crucible with lid	4

3.3 Laboratory chemicals

Consumption of chemicals for 100 complex analyses (classical method)

See part TESTING INSTITUTE FOR NON-METALLIC RAW MATERIALS AND PRODUCTS - D Supplement, page 52

Chemicals for the technological laboratory of a plant manufacturing refractories

Approximately the following quantities of chemicals should be on stock:

Chemicals	g
sodium carbonate	250
ammonium hydroxide	1000
glacial acetic acid	1000
barium sulphate	250
coloured silicagel	2000

Chemicals for technological laboratory in fineness for industrial use

Required quantities of stored chemicals:

Chemicals	kg
sodium phyrophosphate	50
sodium carbonate	50
ammonium hydroxide	50
acetic acid	10

3.4 Laboratory aids

Aids for the chemical-physical laboratory of a plant manufacturing refractories

The laboratory should be equipped by chemical glass and laboratory porcelain as follows:

Aid	Pcs
weighing bottle(ø 40 mm) low shape	24
desiccator (ø 300 mm)	1
desiccator (ø 150 mm)	1

fast filter funnel (ø 60 mm)	12
volumetric flask (50 ml)	12
volumetric flask (100 ml)	12
volumetric flask (500 ml)	6
volumetric flask (1000 ml)	6
beaker (250 ml) low shape	12
beaker (500 ml) low shape	12
beaker (800 ml) high shape	12
pipette (1 ml)	3
pipette (5 ml)	6
pipette (10 ml)	6
pipette (20 ml)	3
pipette (50 ml)	3
automatic burette (20 ml)	2
automatic burette (50 ml)	2
reagent bottle (1000 ml)	6
bottle for indicators	6
porcelain dish (ø 150 mm)	12
filter paper blue band (100 pcs)	2
filter paper white band (100 pcs)	4

Laboratory aids for the technological laboratory of a plant manufacturing refractories

a) Testing of raw materials

Aid	Pcs
sedimentation cylinder by Andreasen	6
sucking flask (5000 ml)	6
desiccator (ø 350 mm)	2
desiccator (ø 250 mm)	2

pipette (5 ml) calibrated	2
weighing bottle (ø 60 mm) low shape	24
weighing bottle (ø 50 mm) low shape	24
beaker (250 ml) low shape	12
beaker (600 ml) high shape	12
beaker (1000 ml) low shape	12
reagent bottle (5000 ml) wide neck	12
Büchner funnel (ø 250 mm)	6
porcelain dish (ø 50 mm) medium shape	24
porcelain dish (ø 100 mm) low shape	24
porcelain dish (ø 150 mm) medium shape	24
polyethylene flask (500 ml) wide neck	24
polyethylene flask (1000 ml) wide neck	24
plastic dish (ø 400 mm)	3
plastic bucket (5 l)	6
porcelain crucible (50 ml) high shape	48
laboratory thermometer (0 - 50°C)	2
slide gauge	1
filter paper blue band (100 pcs)	3
filter paper black band (100 pcs)	3

b) Testing of semiproducts and products

Aid	Pcs
slide rules 250 and 500 mm	2
flat dish 30x50x5 cm for manual glazing	1
protractor	1
angle iron with measuring wedges	1
bucket 10 - 15 l made from plastics	5

calibrated glass vessel (1 l)	3
calibrated glass vessel (3 l) n	3
calibrated glass vessel (5 l)	3

3.5 Required electric power input (kW) for testing refractories

	3 x 380/220 V	220 V
Chemical-physical and technological laboratories	165	19

Built up area:

Chemical-physical laboratory	135 m^2
Technological laboratory	135 m^2

Built up space:

Chemical-physical laboratory	540 m^2
Technological laboratory	540 m^2

LAYOUTS OF LABORATORIES AND PILOT PLANTS

The arrangement of laboratories and pilot plants is demonstrated on planning modules 15 x 9 m. These may be incorporated in groundfloor or multi-storied buildings according to local conditions.

The equipment and instruments dislocated in the modules are designated in conformity with specifications. Only manual appliances and tools are not represented. Rectangles without numbers stand for furniture on which no instruments are placed.

Symbols applied in modules

 el. power distribution 3 x 380/220 V

 el. power distribution 220 V

 water distribution

 gas distribution

Symbols applied in module No. 1, Pilot plant TI/VI

a = beneficiation product

b = input water

c = waste water

d = fine rejections

e = coarse rejections

Guide to modules

	Module No.	Laboratory, Pilot plant
TESTING INSTITUTE FOR NON-METALLIC RAW MATERIALS AND PRODUCTS		
A SECTION OF ANALYTICAL CHEMISTRY, PHYSICAL CHEMISTRY AND MINERALOGY		
I. Laboratory for reception, registration and preparation of samples	1	TI/I
II. Laboratory for analytical chemistry	2	TI/II
III. Laboratory for physical chemistry	3	TI/III
B TECHNOLOGICAL SECTION		
IV. Technological laboratory for testing non-metallic raw materials	3	TI/IV
V. Technological laboratory for testing non-metallic products	4; 5	TI/V
C SEMI-INDUSTRIAL SECTION		
VI. Pilot plant for non-metallic raw material beneficiation trials	1	TI/VI
VII. Pilot plant for semi--industrial trials of non-metallic products	6	TI/VII
KAOLIN WASHING PLANT TESTING LABORATORY		
I. Chemical laboratory	7	KW/I
II. Technological laboratory	7	KW/II

TESTING LABORATORY OF A PLANT MANUFACTURING CERAMIC PRODUCTS

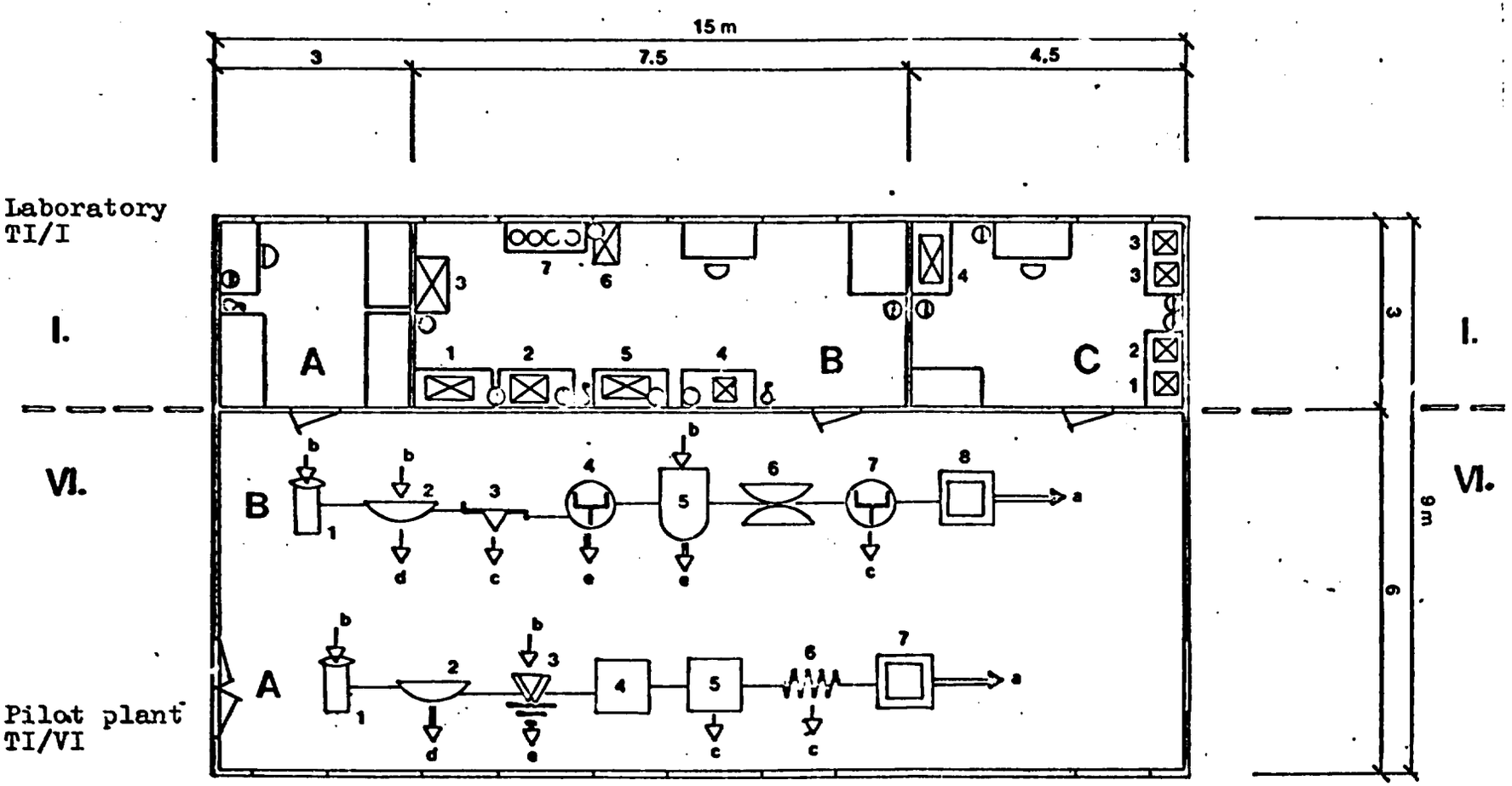
I. Chemical-physical laboratory	8	CP/I
II. Technological laboratory	9	CP/II

TESTING LABORATORY OF A PLANT MANUFACTURING REFRACTORIES

I. Chemical-physical laboratory	10	R/I
II. Technological laboratory	11	R/II

Abreviations:

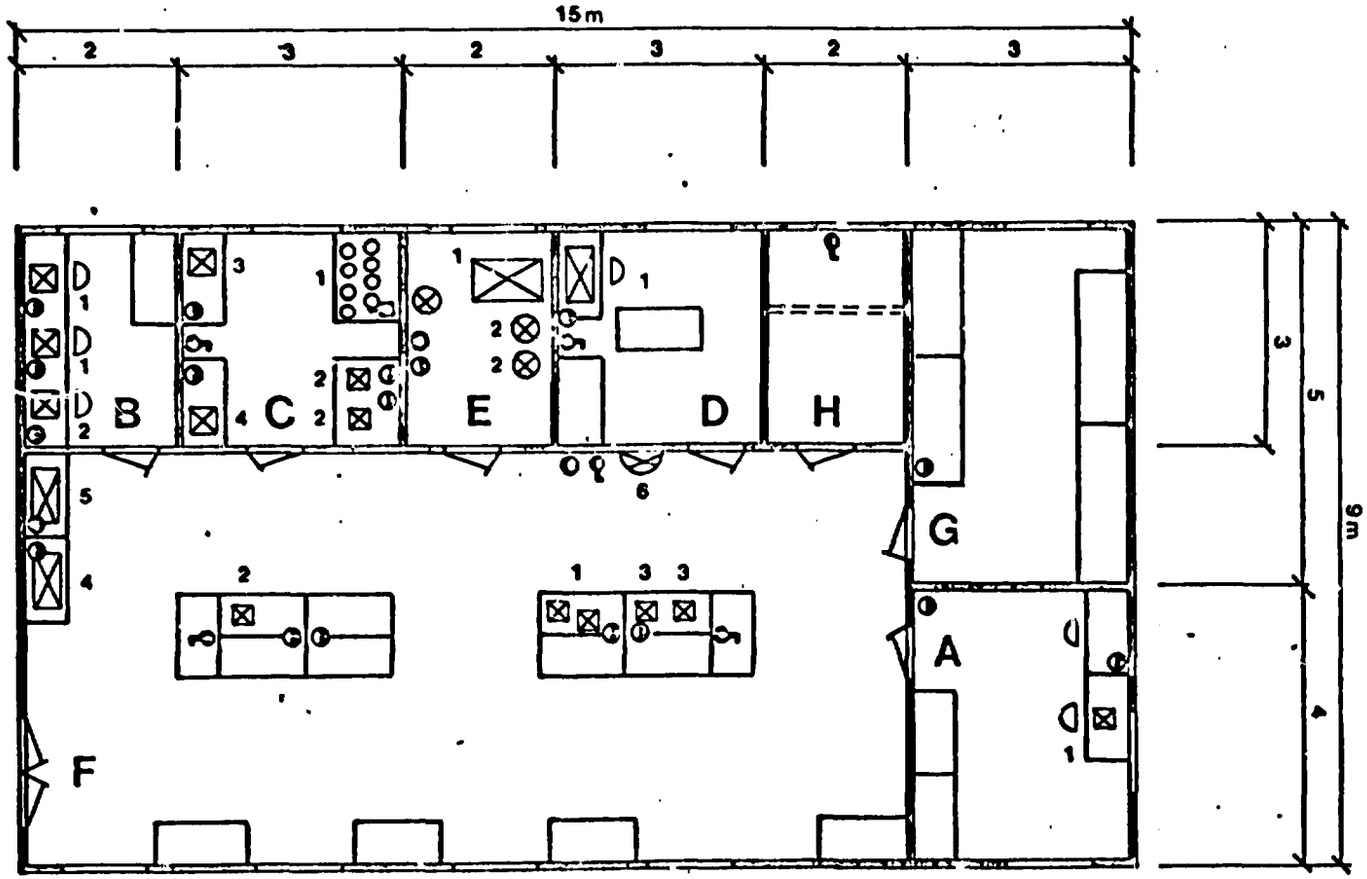
TI	Testing institute
KW	Kaolin washing plant
CP	Ceramic products
R	Refractories



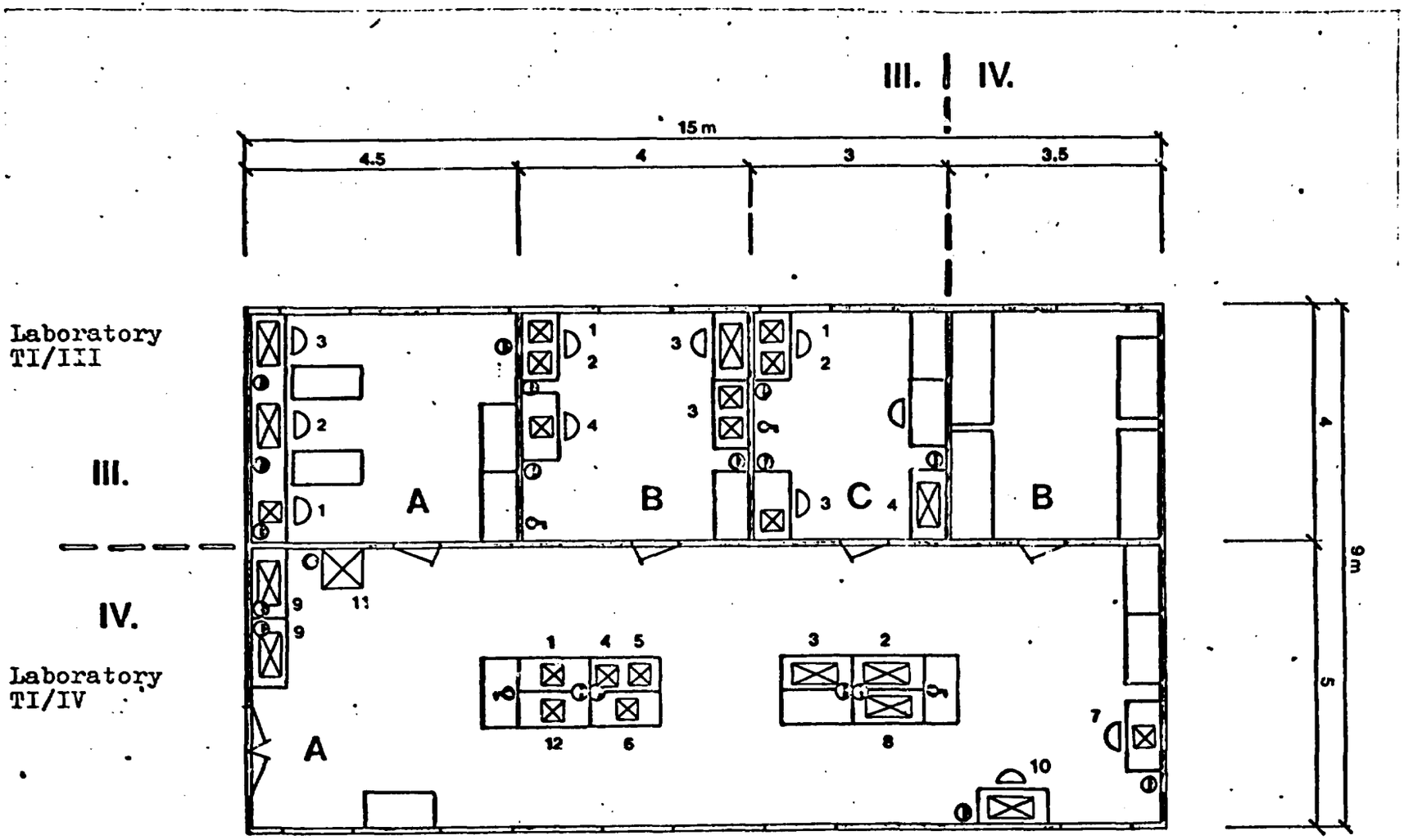
Module No. 1 TESTING INSTITUTE FOR NON METALLIC RAW MATERIALS AND PRODUCTS

II.

Laboratory
TI/II

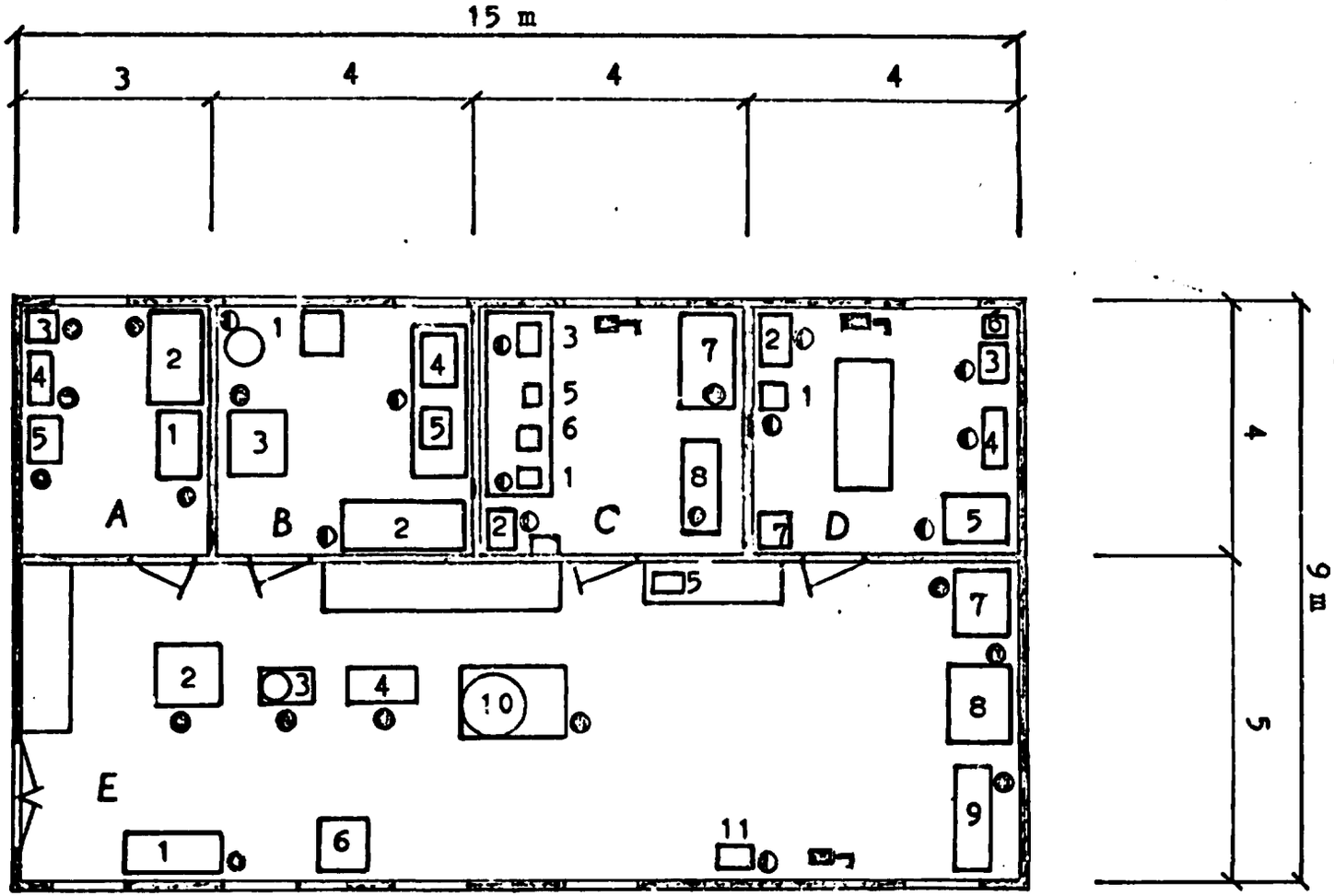


Module No. 2 TESTING INSTITUTE FOR NON METALLIC RAW MATERIALS AND PRODUCTS



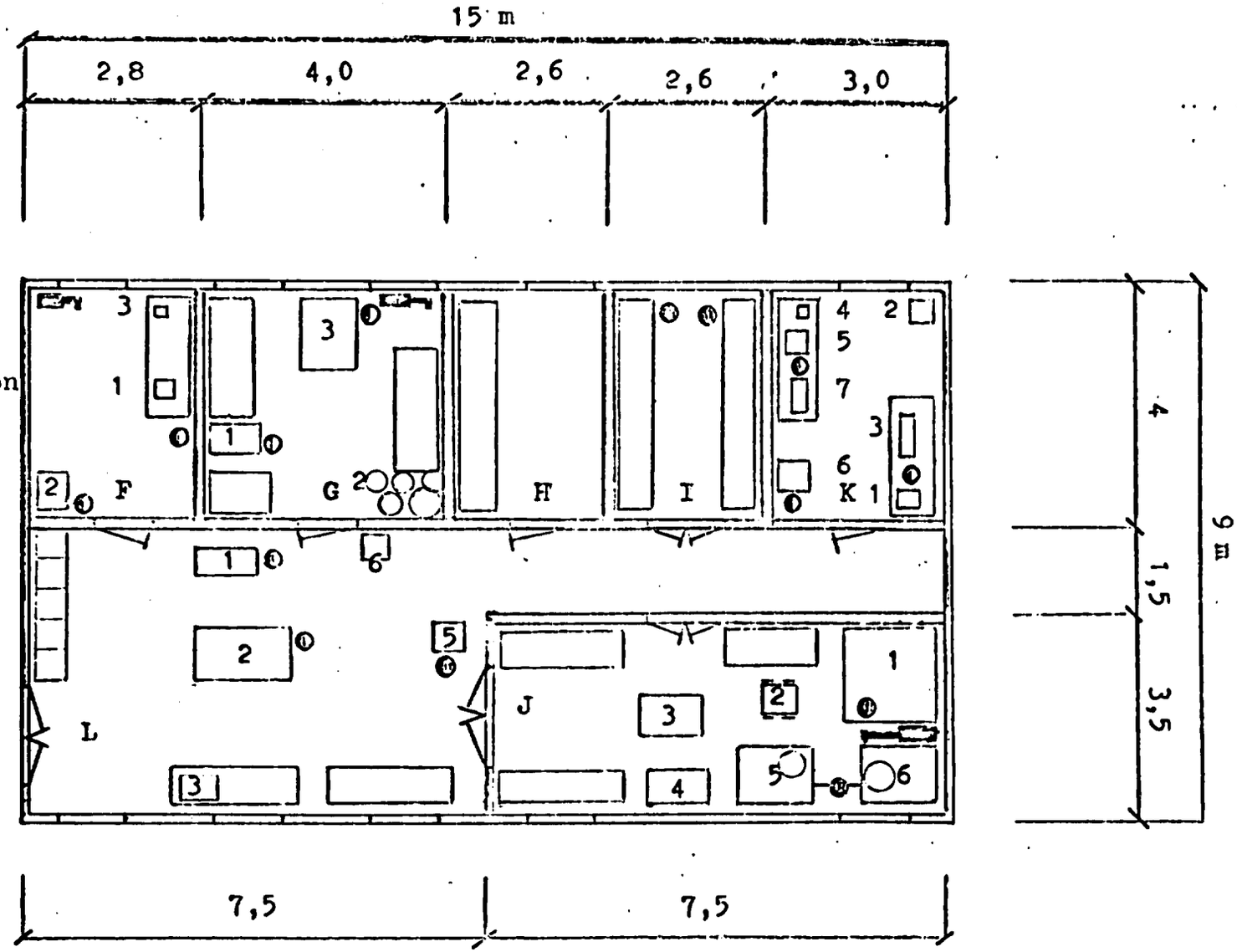
Module No. 3 TESTING INSTITUTE FOR NON METALLIC RAW MATERIALS AND PRODUCTS

Laboratory
TI/V



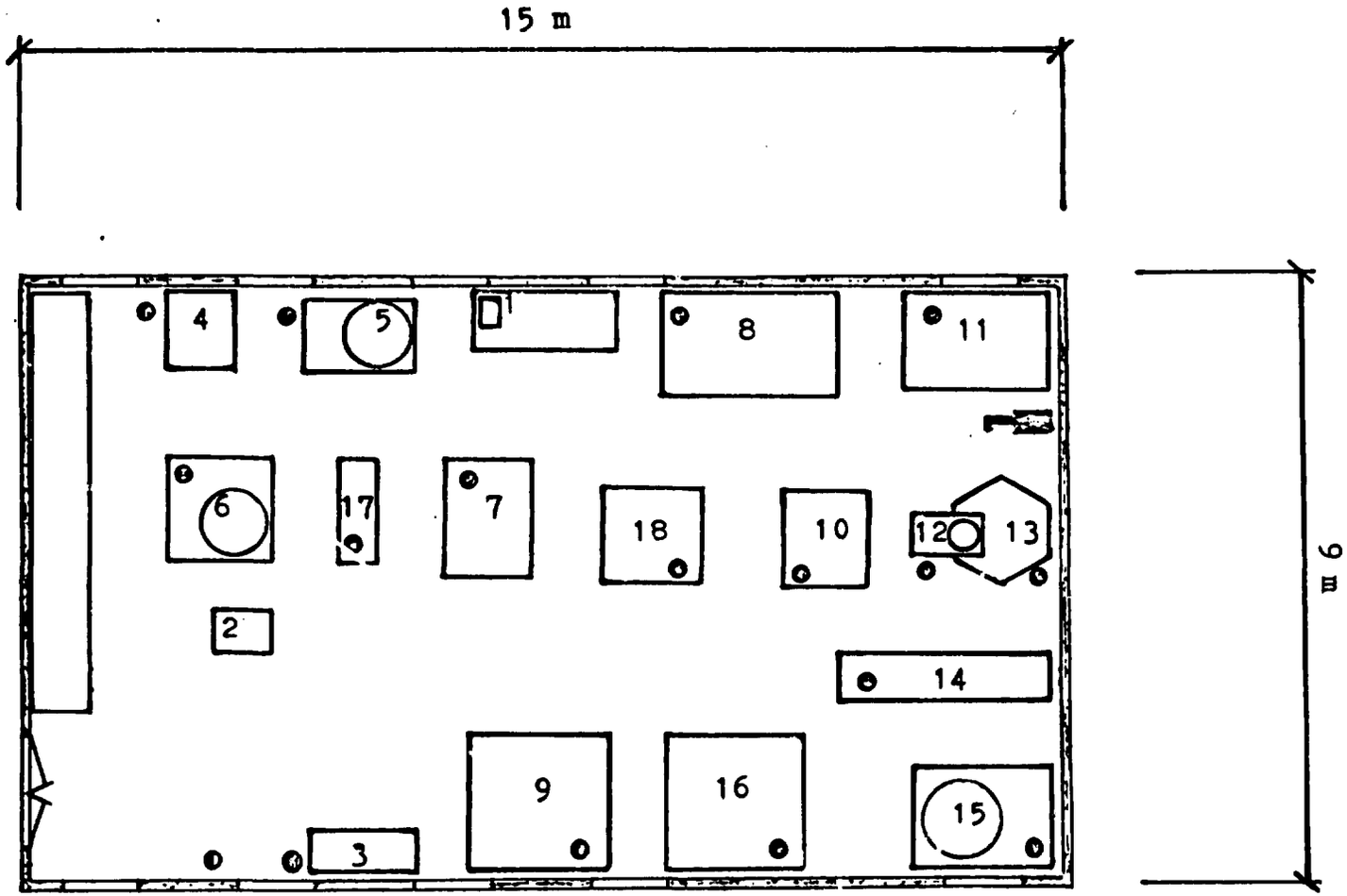
Module No. 4 TESTING INSTITUTE FOR NON METALLIC RAW MATERIALS AND PRODUCTS

Laboratory
TI/V
continuation

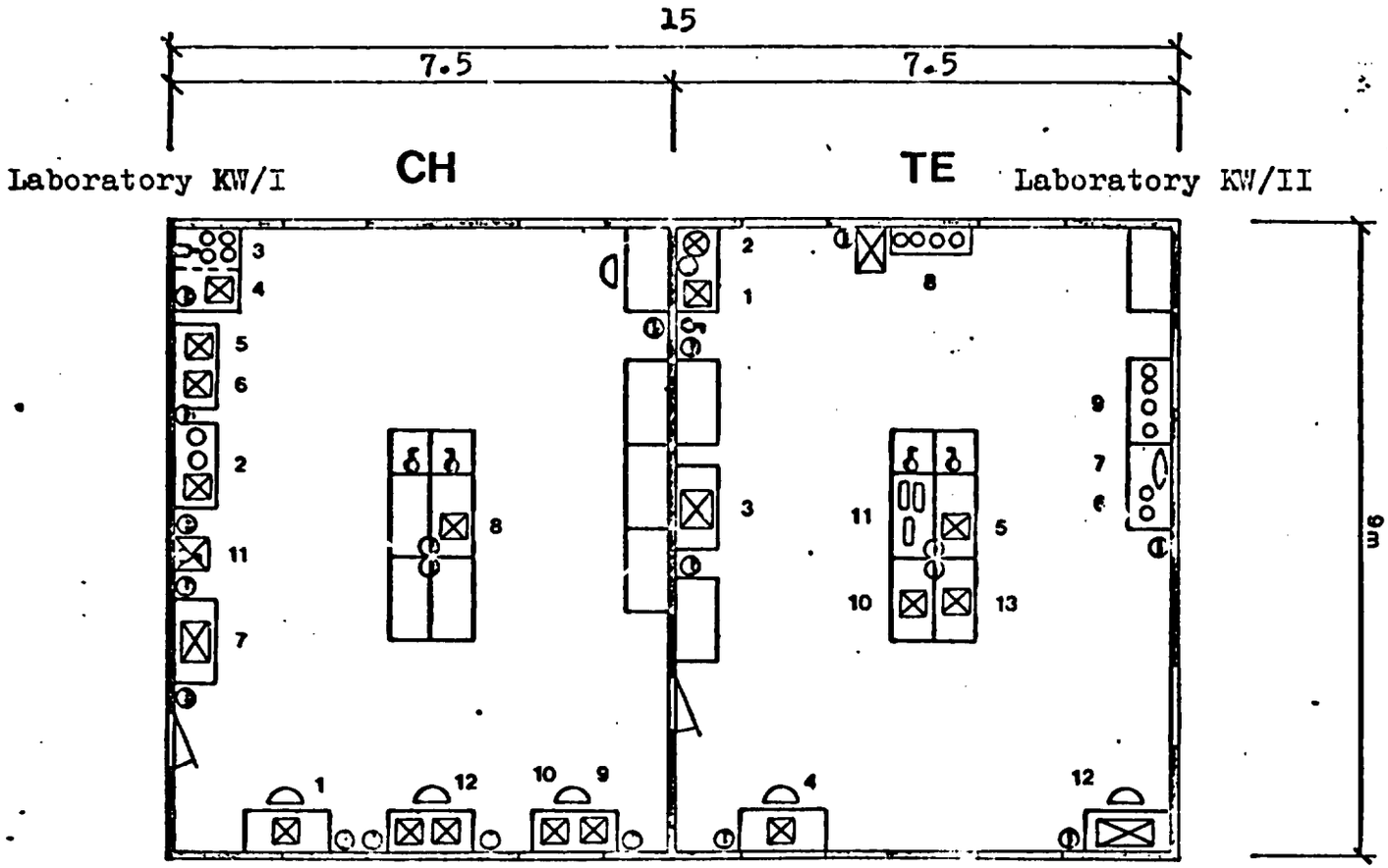


Module No. 5 TESTING INSTITUTE FOR NON METALLIC RAW MATERIALS AND PRODUCTS

Pilot plant
TI/VII

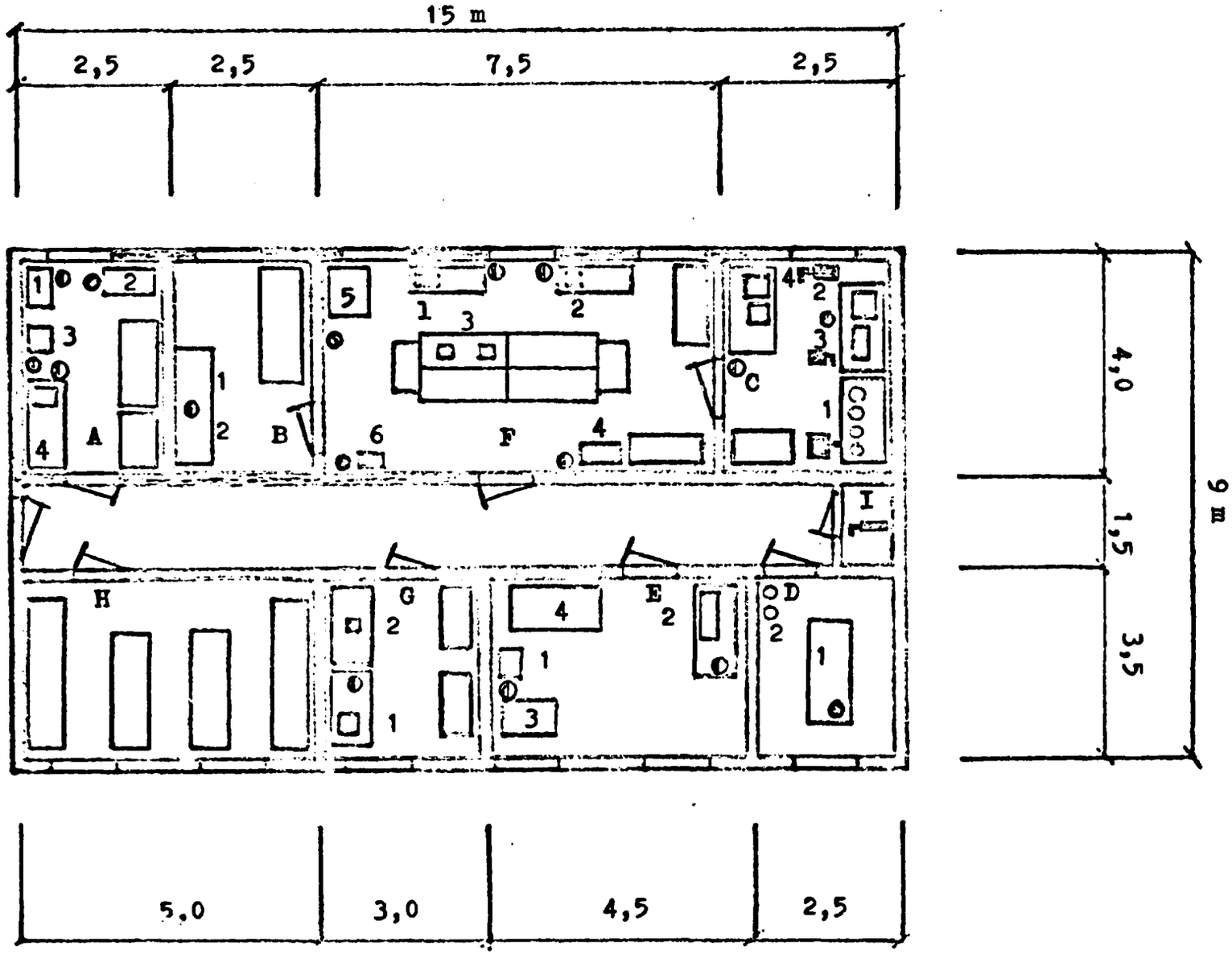


Module No. 6 TESTING INSTITUTE FOR NON METALLIC RAW MATERIALS AND PRODUCTS



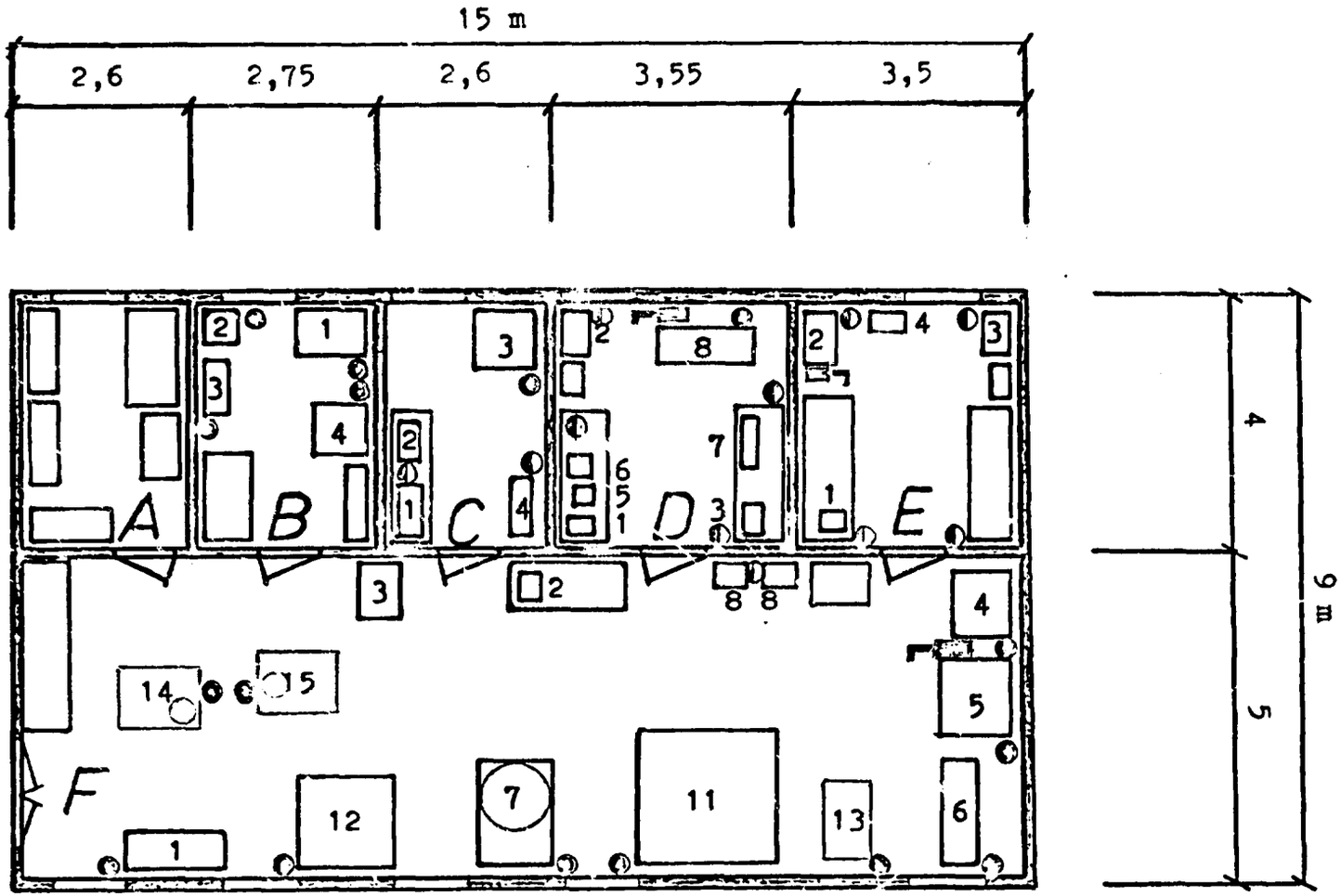
Module No. 7 KAOLIN WASHING PLANT TESTING LABORATORY

Laboratory
CP/I

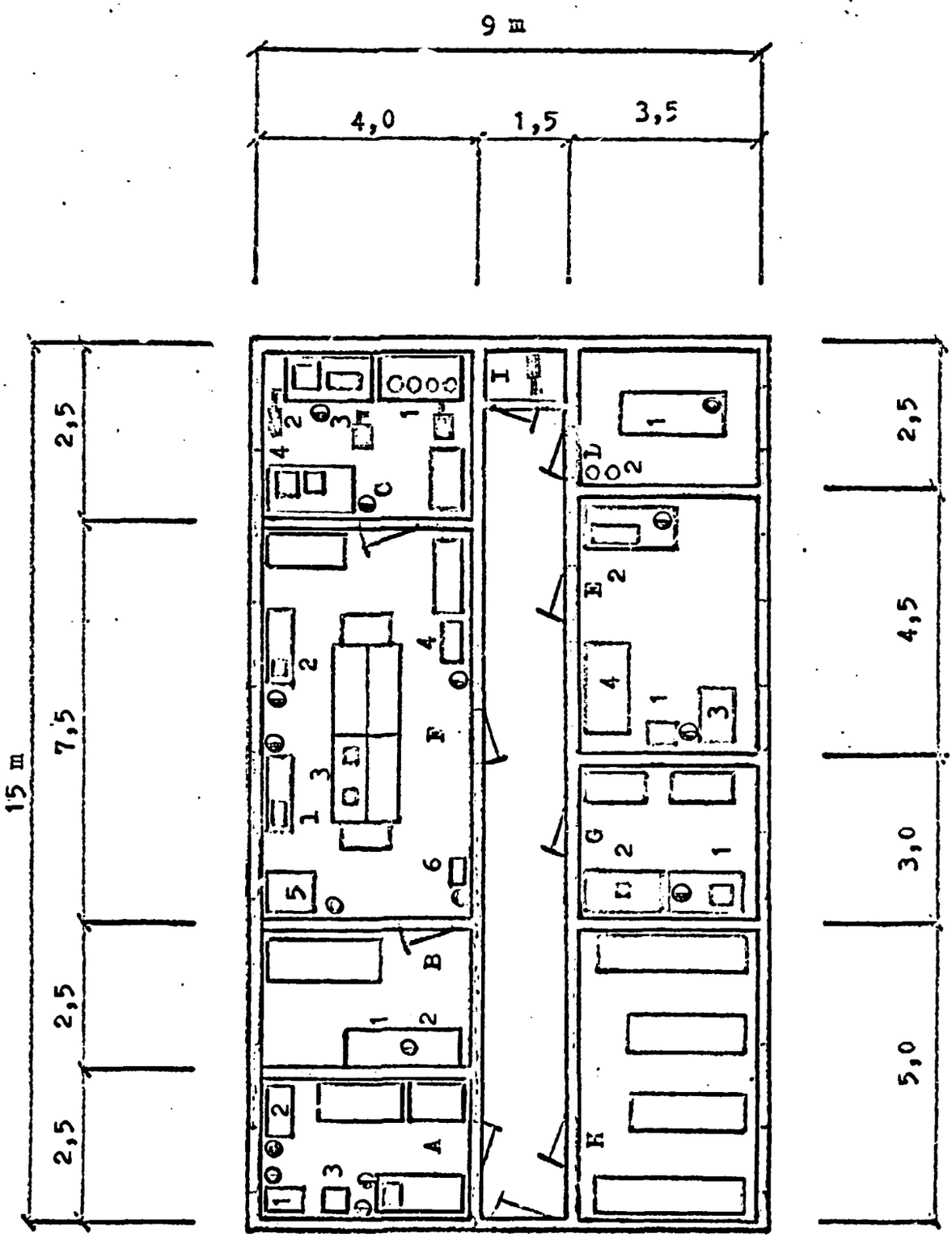


Module No. 8 TESTING LABORATORY OF A PLANT MANUFACTURING CERAMIC PRODUCTS

Laboratory
CP/II



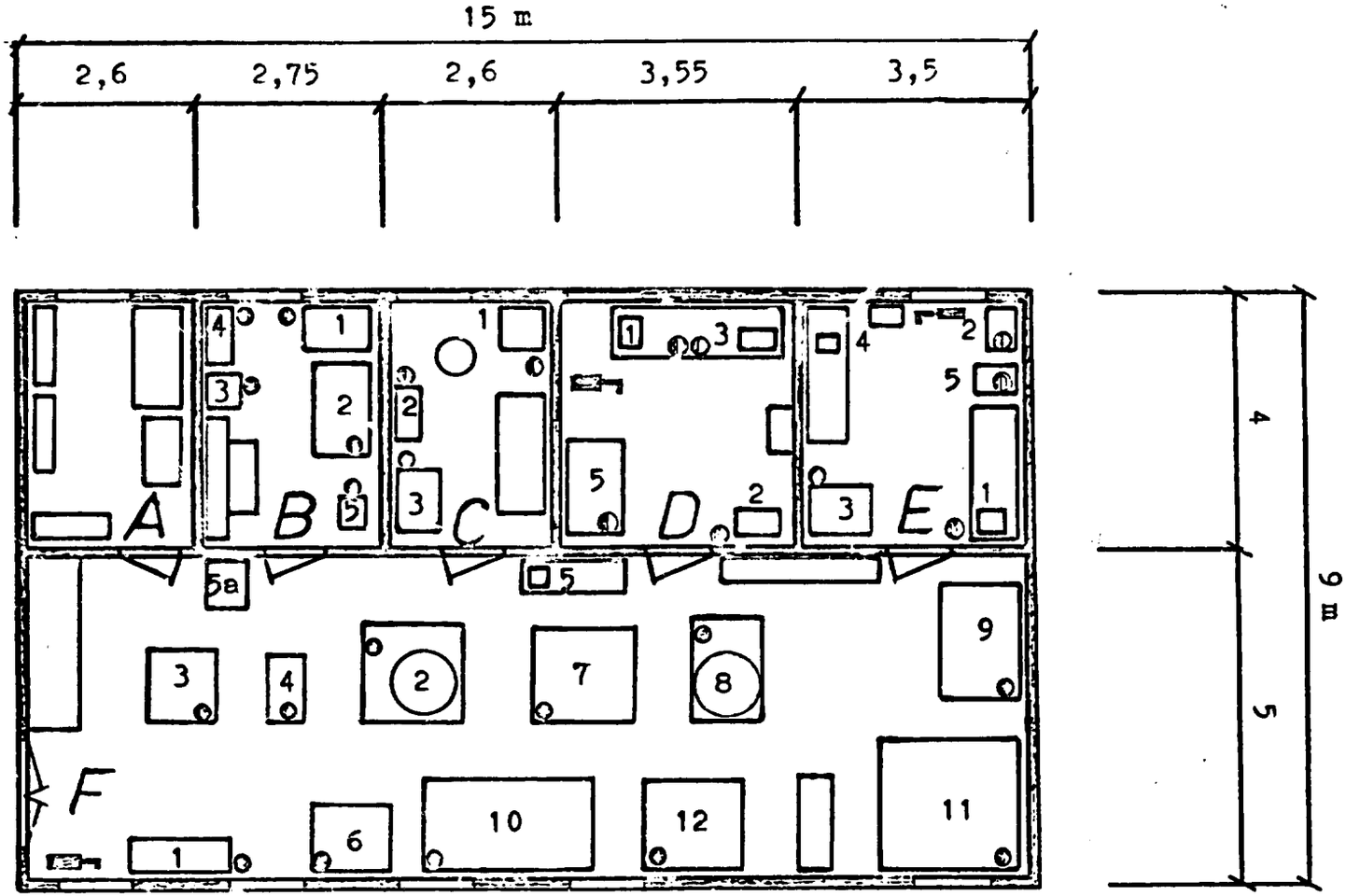
Module No. 9 TESTING LABORATORY OF A PLANT MANUFACTURING CERAMIC PRODUCTS



Laboratory R/I

Module No. 10

TESTING LABORATORY OF A PLANT MANUFACTURING REFRACTORIES



Laboratory
R/II

Module No. 11 TESTING LABORATORY OF A PLANT MANUFACTURING REFRACTORIES

FINAL NOTE

The submitted preliminary projects of laboratories for non-metallic industries represent a review of laboratory equipment in this field of activities. However, a final project would have to take into account local conditions such as local raw materials, assortment of products and planned capacities. In this phase these preliminary projects may serve as a reliable basis for adaptation and preparation of a final project tailored to local conditions, which, if subjected to a feasibility study, will indicate the viability of the implementation and achievement of the set roles of the laboratories in non-metallics consisting in the evaluation of raw materials, orientation of geological prospection, preparation of new technologies, quality control of products and local training of technicians.

This publication is a contribution of the UNIDO/CSSR Joint Programme for International Co-operation in the Field of Ceramics, Building Materials and Non-metallic Minerals Based Industries to the conclusions of the IIIrd General Conference of UNIDO held at New Delhi in January/February 1980 and the fulfilment of the resolution of developing countries participating in the In-Plant Training Workshop on the Exploitation and Beneficiation of Non-metallic Minerals, held at Pilsen, Czechoslovakia, in April 1980.