ECO-Messtechnik GmbH, Kloster-Langen-Str. 22, 26723 Emden

Microwave absorber

Reduction of radar cross section
covering reflection parts at:
Free space measurement
RF dummy loads

Shielded cabinets

EMI measurement
Corona discharge
Protection against data loss
Protection against listening devices

Anechoic chambers

Antenna measurements
EMI measurement
Radar cross section measurement
Measurement of complete Systems
e.g. satellites, missiles, rockets

The ECO-Messtechnik GmbH is an engineers company for microwave technology. It was established in 1980, and the company is based in Emden / Germany.
We offer various components in microwave technology. However, our speciality is the computing and building of anechoic chambers just as the production of the required broadband pyramidal absorbers. They are manufactured in a very modern uc-controlled plant near Emden. We design all desired thickness of pyramidal absorbers in basal surfaces up to 100 x 100 cm. Our Standard absorbers have a 50 x 50 cm basal surface and a thickness of 10 cm, 30 cm and 50 cm. They can be delivered from stock.
For quality control we use a new broadband absorber measurement test equipment which is able to make an attenuation protocol over the wide range from 500 MHz to 18 GHz concerning to the type of absorber.

What are microwave absorbers and their purpose?

It is generally known from acoustics that only in an anechoic chamber loudspeakers, microphones or other sound sources can be measured. These acoustic shielding and absorbing keep away unwelcome sound influences. In order to measure sensitive equipment in the RF-bands the engineers need a chamber which is not effected by environmental electromagnetic radiation. Theoretically the complete measurement equipment can be installed in an area far away from a city to reduce or eliminate the man made noise.
This method is full of disadvantages and for that the free space conditions should be reproduced in a shielded anechoic chamber.
High frequency radiation is an electromagnetic wave and is in confirmity with natural laws. These have been explored and therefore we can minimize the reflections in a chamber. Change of density in a medium always gives a reflection for an electromagnetic wave. By giving the Absorber a special shape and the use of a proper material improves the matching to free space and avoid total reflection. For a lot of measurements microwave absorbers are required. One purpose of use is measuring of antenna diagrams and impedance. Recent measurements refer to the electromagnetic interference, EMI. Because of the increasing number of electrical equipment undesirable interference is often the result of RF-radiation.
In the civilian area e.g. video recorders could be disturbed by an amateur radio station in the neighbourhood. These problems are mostly conditioned by the construction of the disturbed device and should be eliminated by an exact measuring in an anechoic chamber.
Computers, both great calculators and home Computers, transmit electromagnetic radiation which can make an interference to TV or radio sets.

These sturgeon radiations too can only be determined in a shielded chamber. Because of the multiplied application of electronic Systems in a car, interference between the Systems and external radiation occurs.
Here too an anechoic shielded chamber is necessary to measure a complete car. The military also uses shielded anechoic chambers to measure e.g. missiles or complete Systems. Sometimes these measurements are actually still made in free field conditions, however it es planned to build chambers big enough to measure complete airoplanes. The camouflage of military objects needs also anechoic shielded chambers and turns them to good account. At least universities need our absorbers to cover the walls, floor and ceiling in their antenna laboratories. The ECO-Messtechnik GmbH conceives and delivers on customers requirement, every shielded and anechoic chamber which is practicable. Even an improvement of existing chambers is possible through new and better absorbers. We also offer an exact measurement of your chamber not only for existing chambers but also for new ones. ECO-Messtechnik GmbH uses the most modern test equipment at present and we prove shielding attenuation about 100 dB. The following pages shall give you some information about the absorber technics including original data sheets of our broad-band pyramidal absorbers.

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Introduction Summery

Hereby we present our various types of microwave absorbers, both narrow-band and broad-band material.
A simple introduction avoiding scientific treatment covers the different types of material on the market, indicating not only their characteristics and properties but also their nature, uses und applications, as well as the reason for their selection. This short survey should enable the prospective user to get acquainted with the possibilities and to gather the necessary elements for asking us to make a proposal. Our experience in the manufacturing of absorber materials as well as in the design and mounting of anechoic facilities will be available to you under the form of preprojects with corresponding offers or in advice for your own preproject studies. Of course we will, also gladly advise in matters not fully treated in this small survey or even
completely beyond its scope. This applies e.g. for special materials such as high-loss dielectrics for waveguides e.g. and for high temperature composite materials, resins, and bonding agents etc ... which we also carry in our product lines. It applies also for such materials as may be required for R. F. shielding of anechoic or other facilities, for dustfree clean-room conditioning as well as for other more usual servicing requirements for such buildings.

Basic principles in microwave absorption

Microwaves, varying from the millimeter range to several meters wavelengths, are often used because of their physical peculiarity that they are reflected by almost any material in the non-gaseous form. So they constitute a powerful means for obtaining complete pictures of large and even of distant objects or areas.
Radar is a well known example of such use. Quite often it is also necessary to protect against such microwave radiation or to shield it off. Thereto one must look for efficient microwave absorber materials.
However, since practically all materials more or less reflect rnicrowaves, only very few materials are good for absorbers. Therefore, it is not easy to conceive and to manufacture materials with a high capability of absorbing microwaves. The problem is complicated even more because of the fact that unlike the more commonly known radiations (e.g. optical light, X-rays, radioactive radiation, etc...) in practical use microwaves behave considerably more as waves than as lightbeams, so that besides specular reflection special characteristics have to be taken into account such as diffusion, deflection and standing waves.
This makes it rather difficult to predict absorption and reflection by materials and surfaces. Computing microwave radiation effects in areas under their influence such as microwave test ranges and anechoic chambers requires very special treatment. A very important characteristic of microwave radiation besides its intensity (or power) is the wavelength or, inversely proportional to it, the frequency.
Obviously the requirements for microwave absorbing materials will considerably differ with the wavelength or the frequency range considered.

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Microwave Absorbers

Microwave application development has made it necessary to conceive special materials capable of highly absorbing such radiation: they are called microwave absorbers. In addition to their use for shielding off energetic microwave radiation and in this way protecting man against eventual noxious effects, they have also been widely used to shield objects and equipment from microwaves or also to hide microwave sources from detection. One of the more spectacular applications, however, is their use in microwave anechoic chambers, e.g. for use as antenna pattern-ranges and as radar backscatter test ranges for the evaluation of radar targets, going from small cubicles to extremely large installations.
In these, microwave absorbers are skilfully mounted on walls and ceiling and sometimes on the floor as well so as to provide a "quiet zone" or "dead zone" in which reflected radiation is kept to a minimum and so called freespace conditions for E.M. radiation can be simulated.

Manufacturing: (Production)
Because microwave absorbers are cut of a foamed plastic block, there might be a light tolerance in pyramid heights, as well as in the dimensions of the basic mass and a light change of the pyramid top-points (the top-point can be broader). This tolerance can amount in the basic measure up to 5% and in pyramid height up to 5%, which appears as manufacturing-conditioned and cannot be avoided. Different mass have no influence in the attenuation quality of the absorbers; there also might be different pore dimensions and a slightly color difference with the black absorbers; this also is manufacturing-caused. Within color absorbers the difference is very low.

The wide variety of applications both of the microwave absorbers, and the microwave anechoic chambers are beyond the scope of the present description.
Here we rather approach the subject from the practical point of view of the engineer who is looking for advice when confronted with a need for absorbing materials or anechoic space facilities.
Our staff is certainly also available for advice as well in the field of microwave materials in general, as in the shielding of other types of radiation of any nature.
This guide, however, mainly covers the properties of various types of microwave absorber materials and their use in anechoic facilities.
We will limit the theoretical aspects to simple introductions, sufficient for understanding their rational use, and we refer for more fundamental treatment of the subject to specialized literature.

Narrow-band and broad-band absorption

High frequency radiation (of cm and mm waves) will in general be absorbed more readily by small-sized absorbing shapes than lower frequency microwaves.
In general one can reach approximating estimates for the attenuation by appropriate,
good quality absorbers, as follows: an attenuation of ca. 30 dB when the absorber height equals the wavelength, approx. 20 dB when only 2/3 and approx. 40 dB when double the wavelength.
For larger wavelengths, say from 80 cm on, this approximation is not entirely valid because of the deflection in case of insufficiently large shaped absorbers.
Basically two principles are used in the concept of special material for absorbing microwaves.

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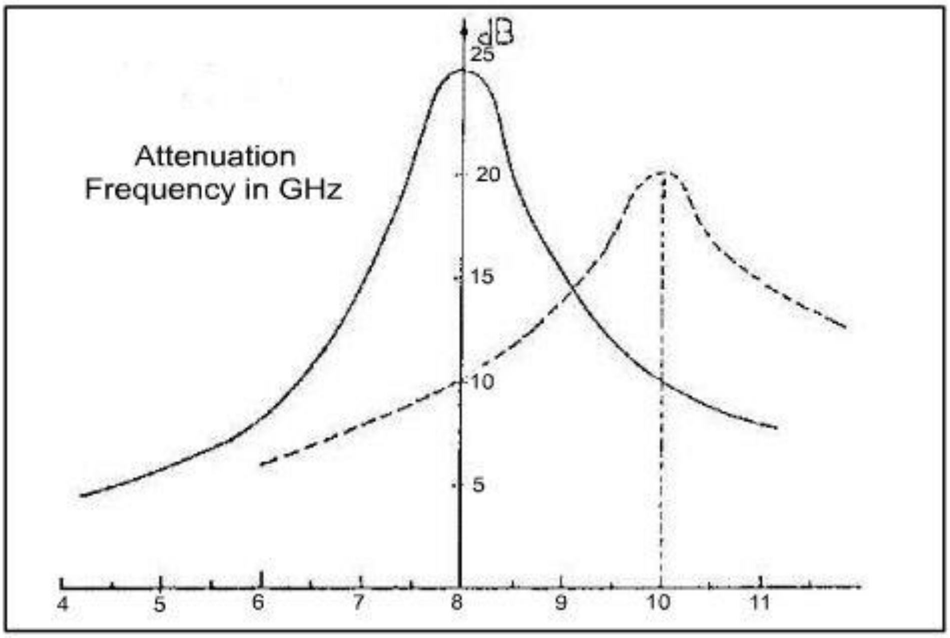
Narrow-band absorbers

Such materials consist of a layer with parallel surfaces.
They are conceived in such a way that the wave reflecting from the upper surface of the absorber is roughly canceled by that pari of the wave which went through the material and is reflected from the lower surface.
Thereto the later reflected wave must be off-phase from the directly reflected one by approximately one half wavelength.
The thickness of the layer will depend on the value of the wavelength itself and of the angle of the incident radiation.
Consequently, the material must ref lect approximately as much of the incident wave as is coming out in the same direction after having passed down and up through the material of the layer.
Moreover, the thickness of the layer will be determining for the wavelength and thus for the frequency range; this will, of course, be a rather narrow band.
Because the reduction of the reflected energy is mainly obtained by the interference of directly and indirectly reflected radiation, such absorbers are also called interference absorbers.
Narrowband absorbers are mostly used for shielding of parts around antennas, targets or other equipment, exposed to a specific wavelength, which determines their thickness.
In general the weakening called attenuation of the incident radiation by a narrow-band absorber drops fairly rapidly when the frequency differs (up or down) from the main frequency for which it is designed.
The attenuation is commonly expressed as the number of decibels (dB) that the reflected radiation is down compared with the incident radiation.
In function of the wavelength the attenuation by a narrow-band absorber follows a bellshaped curve.



Typical frequency-dependent attenuation curves for narrow-band absorbers
___ for types under 10 GHz (example Ecomp St 8, for 8 GHz)
- - - - for types above 10 GHz (example Ecomp St 10, for 10 GHz).
Peak values over 25 dB are exceptional because of the nature of the material composition.

At higher frequencies, say from 10 GHz upwards, the peak value decreases (to 20 dB, or even lower) because of the inherent difficulty to produce sufficiently accurate layer thicknesses.

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The limited band width of these interference absorbers is often a draw-back. Therefore, many attempts have been made to produce multilayer absorbers based on the interference principle, but so far none can be considered as a Standard product. Research is going on, however, at Eco-Messtechnik GmbH, so that in particular cases we can be contacted for advice.

Broad-band absorbers

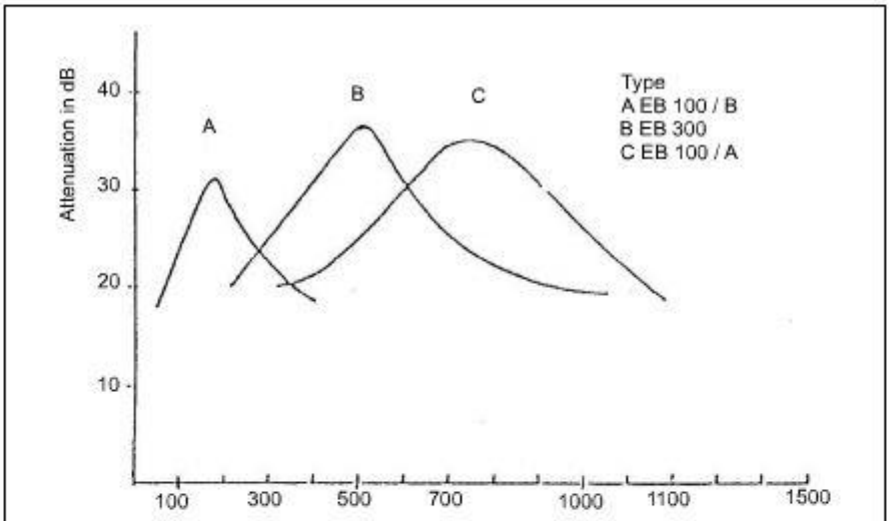
In these types of absorbers, particularly for the dm- and cm range electromagnetic waves, a high loss or attenuation is obtained by the incorporation of an electric loss producing substance such as carbon into a matrix, in a particular way.
Most often the matrix is a soft material such as polyurethane foam, dimensioned and shaped in an appropriate way, depending on the wavelength of the microwaves. In other cases the absorption is based on magnetic loss produced by the incorporation of ferrite materials in a more solid matrix. These are, however, considerably more expensive and of more limited use.Broad-band materials are extremely well suited for the shielding or attenuation of microwave laboratories and antenna or target measuring ranges of any size. In these the excellent attenuation allows to measure under free-space conditions obviously independent from weather or climate.
A few examples of use are: recording antenna directivity patterns, determining radar scattering cross sections, measuring of antenna boresight, checking of airborne radar equipment, studying electromagnetic interference and electromagnetic compatibility of emitters and receivers as well as of a large variety of objects such as vehicles, weapons, satellites, telecommunication equipment, etc ...
The increasing electromagnetic pollution of our environment is opening a wide field of application for microwave absorbers to shield off unwanted influences of intentional or not-intentional interference with Computers protheses, electronic equipment in cars, airplanes, etc... which have been considered or suspected as the cause of accidents.
In most of these cases it is recommended or necessary to shield off a widest possible range of wavelengths to provide optimum protection; also this can best be achieved by means of broad-band absorbers.
There are also anechoic chambers designed for the determination of electromagnetic compatibility (EMC) between components as well as for the study of electromagnetic interference (EMI).They can also be useful for the study of electromagnetic pulses (EMP).
A particular attention for this field derives amongst others from the possible danger of so called nuclear electromagnetic pulses (NEMP) feared for from nuc-lear detonations at several kilometer heights.

Flat absorbers

Although we offer a complete variety of magnetic loss absorbers presently on the market, we really consider the weatherproof, heatproof (to 250°C) varieties of great importance because they are unusual and nearly unique in covering the VHP and UHF ranges (between 70 MHz and 1200 MHz). They are for very low frequency range the only thin material (5 and 8 mm) available.
They come in tiles of 60 mm x 60 mm or of 100 mm x 100 mm and have been used in anechoic boxes and chambers as well as for suppression of TV-ghosts due to buildings.

The ferrite type absorbers

Among the various types of flat absorbers that have been proposed and used in the past, we have only retained in our program (besides the interference absorbers already discussed) the special low-frequency materials bases on ferrite materials and, as will be discussed later, some floor absorbers. Indeed, there are advantageous substitutes for the other types of flat broad-band absorbers.



Pic. 2

Flat foam type absorbers

Flat absorbers have the disadvantage that from a given angle of incidence onwards, and depending on their electromagnetic properties (compared to those of the surrounding matter or atmosphere), waves can bounce off the surface without much absorption or attenuation.
Consequently, the surface layer of such absorbers cannot always be loaded with the absorbing substance so much as would be desired for optimum absorption properties.
This problem can be solved by incorporating a gradient of the absorbing element throughout the thickness of the absorber.
One way of achieving this is by using two or more layers of material of varying composition.
Another and more easy way to improve absorber properties is the use of indentated surfaces which present a continuously varying surface angle to the radiation.
This not only causes increased penetration into the absorber material, but it also diffuses the reflected radiation considerably, thus weakening its effect. For practical reasons both flat and indentated

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surface absorbers are limited in thickness, and, consequently, become less effective at lower frequencies.
Some companies offer flat materials up to thicknesses of 10 cm and indentated-surface material up to 25 cm, or even thicker combinations of both types, so as to provide for some attenuation at frequencies down to 1 GHz or even 0.5 GHz, but those multilayered absorbers of large thickness are expensive and can mostly be replaced advantageously by pyramidal shaped absorbers. Pyramids have the advantage to combine somehow a gradient
of absorbing matter presented to the perpendicularly incident wave front with the diffusion properties of the indentated surface while providing deeper pits or valleys be-tween the tips in which radiation gets lost by multiple bouncing back and forth. Pyramid tips must have afairly particular angle so as to optimize absorption. Consequently, the number of pyramids constituting one absorber unit differs with size, i.e. also with the lower frequency use. Good absorbers made of ten cm high pyramids provide an attenuation of perpendicularly incident waves of 40 to 45 dB at 10 GHz and higher frequencies.
For the higher frequencies smaller pyramids could be made, but they are little if at all more efficient than the less expensive indentated type material.

For lower frequencies, pyramids of 20 cm and more, up to 4 meters are available providing about 50 dB from a given frequency up, and lower attenuations for the lower frequencies going down to somewhat under 100 MHz. Under 100 MHz the larger pyramids (^ 2 m) have still a serious effect which is of the same order of magnitude as attenuation by means of thin ferrite tue absorbers. While being both expensive, the latter have the advantage to keep the chamber dimensions low, but large pyramids have the advantage over them that they retain excellent absorption properties at higher frequencies, whereas the ferrite materials do not. Therefore, in most cases broad-band absorbers will be preferred.
Sometimes ferrites will be used in combination with them to save space or tiles will be used alone in smaller facilities where the application is limited to the lower frequency range.
General attenuation properties of pyramidal broad-band absorbers.

The following curve (fig. 3) represents the general trend of the attenuation of perpendicularly incident radiation in function of the frequency.

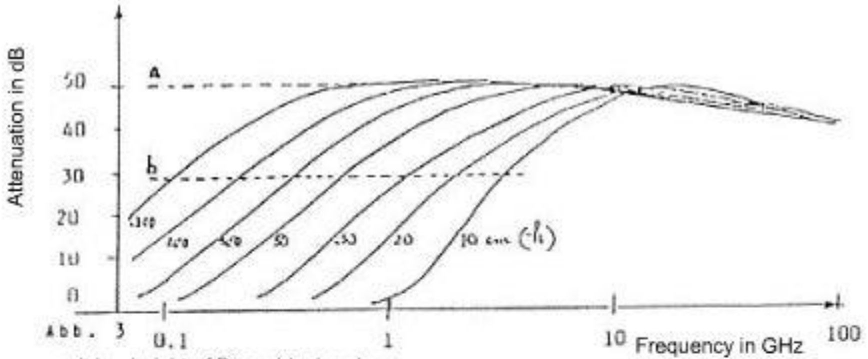


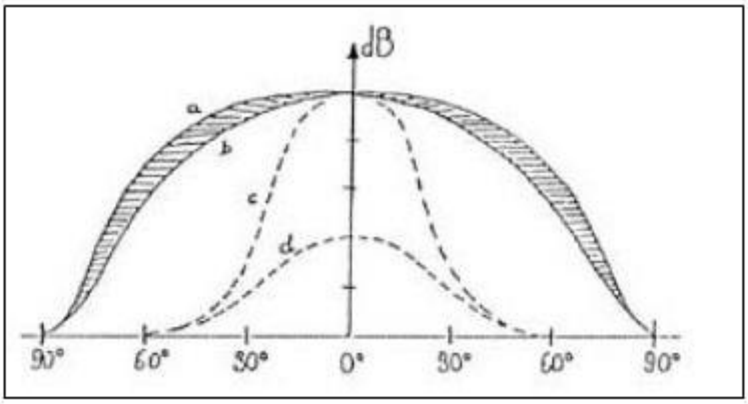
Abb. 3

mit h = height of Pyramideabsorbers
mit f = frequency of perpendicular microwaves

The S-shaped curve in is deplaced to the right or to the left depending on the size of the absorbers.
a (50 dB) is the lower frequency limit of füll attenuation.
This value is valid to around 20 GHz from where it Starts dropping down slightly to approximately 45 dB around 35 GHz and approximately 40 dB around 95 GHz.
b (30 dB) is a characteristic lower value of the frequency arange for use as high efficiency absorbers.
Obviously these absorbers can be used with lower attenuation effect (5,10,20 dB) at lower frequencies.

Incident angle dependency

Attenuation of incident microwaves differs of course with its angle of incidence and eventually with its polarization.
For pyramidal absorbers the Variation is not so large as for f lat absorbers because of the different angles of exposure of the surface of the pyramids.
As can be seen from fig. 4 ca. 2/3 of the maximum value (corresponding to perpendicular incidence) is still retained up to incident angles of 60°.
Values vary somewhat (between curves a and b), depending on polarization and direction of pyramid rips.
It is clearfrom curves c (for perpendicular polarization) and d (for parallel polarization) applying in the case of flat absorber types, that these are not so efficient for parallel polarized waves as for perpendicularly polarized ones, but in either case they bounce off fully from a given angle onwards.
Indentated surface avoid this and give roughly indentical attenuation results for both polarisations.
Therefore we mostly recommend this type of indentated material rather than the flat types, price differences being rather in favour.



—— General trend of the Variation of reflectivity values a function of incidence angle for pyramidal absorbers
- - - compared to that flat type absorbers

Special type absorbers

The design of microwave anechoic chambers, both with a limited quiet zone area (as for target or antenna measure-ments e.g.) as without (as for EMC and EMI work) has undergone considerable changes in the course of time.
The importance of layered flat surface absorbers from the early days, necessitating the use of baffles and protrusions, both longitudiually and perpendicularly, has diminished due to the evolution of high quality indentated and pyramidal absorber types.
Uneven room surfaces and baffles are still used but only in cases where the extra costs involved are justified or can even be offset.
In anechoic rooms equipped with large pyramidal absorbers special rather oom and in its corners.
This expensive solution can be avoided by appropriate selection of Standard absorber types of smaller height. We have developed this technique to such an extent that no rib type or corner type absorbers at all are necessary.
The only particular types of absorbers still useful in anechoic facilities are walkable floor type absorbers.

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Obviously, for quite some uses, it can be sufficient to keep a series of Standard absorbers at hand which can be placed loose on the floor surface. But in other cases the use of special floor absorbers can be convenient.
Sometimes it is sufficient to limit their use to a working platform around or behind the turntable or target-mounting area and an access walkway, possibly away from the directly reflecting zone on the floor.
In other cases, e.g. in EMC study chambers where a large part of the floor surface is used, permanent walkable floor absorbers can be requested.
Obviously, such floor absorbers are not only more expensive than the regular ones,
but the space taken up by such absorbers generally necessitates more overall room height and, consequently, a higher and more expensive building.
Accordingly the height of permanent floor absorbers will be kept as low as possible and will therefore in most cases be inferior to that of the wall absorbers.
Obviously do floor absorbers exhibit inferior attenuation properties than Standard normal absorber types.
Different types of floor absorbers are offered depending on the size of removable absorbers which they replace.
For indentated material there is a special floor version using a male-female combination of absorbing and non-absorbing substance, with a walkable cover.
They can be used in combination with other surface covers (plywood, PVC, etc...) to be selected for minimum reflectivity.
When somewhat broader frequency ranges (towards the lower frequencies) are involved, a new special foam floor absorber is recommended consisting of the regular pyramidal material in a fireretardant hard foam matrix.
Its E.M. properties approach those of the pyramidal material.
For larger pyramids (and certainly from 80 cm upwards) either a separate supporting structure is to be foreseen under which Standard absorbers can be used, or a special concept of supporting absorber units is to be adopted. This varies from case to case depending on size of the absorbers, size of platform, maximum load capacity, maximum torque on floor, a.s.o..
Basically, each absorber then consists of supporting wooden beam, draped by absorber pyramidal material.
Sometimes four, six or nine absorber units can be handled together by means of a forklift.
The wooden beamtops are fastened to each other in different ways, so as to constitute the platform support.
Appropriate proposals will be presented upon detailed request.

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Other physical properties

The restriction of commercial absorbers to a limited number of types sufficient to cover practically all field applications has made it possible to improve attention to other physical properties.
Most important amongst these is the fireretardacy.
It is obvious that the chemical nature of the materials used in absorber manufacture is such that these can burn at least in the presence of a flame.
They must, however, exhibit excellent fireretarding and selfextinguishing properties.

Our materials are self-extinguishing in accordance with ASTM -D1692 - 74 and ASTM - D - 1692 - 59T, and they can be considered as incombustible in the sense that they are flame-retardant by ASTM method EL 36 - 59T (Mod.).
Tenure of our absorbers and their physical and electrical properties at normal below zero temperature and at 50° C are no problem. For under —20° C or above 50° C please consult.
The power handling of the broad-band absorbers is of the order of 0.2 to 0.3 watts/cm2, which is largely sufficient for most applications.
For five to ten times higher power absorption narrow-band absorbers should be considered, or we should be consulted.
In general, broadband absorber materials are black. As such they are, of course, also good optical light and IR (infrared) absorbers.
Against a slight price increase they can be supplied in different colours, varying from gray to broken white, as well as blue, red etc...
The coating very slightly reduces the attenuation performance of the absorber,but it can be justified in particular applications.
We recommend e.g. the use of coloured absorbers on access doors, so as to clearly indicate their location.
A similar coating treatment can be applied to the absorbers to make them appropriate for dustfree environment of clean-room conditions.
The surface obtains a finished appearance which prevents the abrasion of small particulate matter under slight friction.
More heavy duty treatment by means of neoprene-based materials renders the absorbers impervious to liquids and weatherproof for outdoor and airborne use.
Their price again is somewhat higher then that of the Standard material.